INACCURATE DATA ENTRY INTO THE AIR FORCE MAINTENANCE DATA COLLECTION SYSTEM

THESIS

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Abstract

This study investigated the data collection environment under the Core Automated Maintenance System (CAMS), a computerized information system used in the Air Force's aircraft maintenance complexes to aid maintenance managers in maintaining aircraft. The research used a survey to measure maintenance personnel's perception of the nature, extent, and causes of data inaccuracies occurring in the CAMS data collection environment. The nature was differentiated as being either intentional or accidental, with 10 % of the total errors occurring attributed to intentional causes while 90% were attributed to accidental causes. Maintenance personnel felt that difficulty in entering information into CAMS accounted for the largest percentage of intentional errors and that insufficient training on CAMS accounted for the largest percentage of accidental errors. Additionally, the results of this research were compared to the results of earlier research conducted by Capt Thomas Folmar who measured the perceptions of data inaccuracy under the Maintenance Data Collection (MDC) system; the system which CAMS replaced. In general, the rank of the maintenance personnel had a significant effect on the way they perceived data inaccuracy. The workers (AB-SSgt) perceived no increases in data accuracy under CAMS, while the supervisors (TSgt-CMSgt) and managers

(2lt-Col) were mixed in their perceptions of data accuracy improvement under CAMS.

The maintenance personnel were asked what they perceived to be the most significant contributor to data inaccuracy in the CAMS environment and what actions they would take to improve the situation. There was an overwhelming perception that lack of training on CAMS was the most significant cause of data errors and a suggestion that a training program may help to improve the data accuracy.

In conclusion, the evidence presented in this research supports characterizing the nature of errors as intentional or accidental. Additionally, the evidence suggests that the research's initial attempt to categorize the causes of data errors occurring was successful. Finally, rank was a significant factor in differentiating maintenance personnel's perceptions of data inaccuracy.

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I. Introduction

General Issue

Decision makers throughout the government use computerized information systems as an integral tool in their decision making processes. The Core Automated Maintenance System (CAMS) is a computerized information system "used at base-level to manage maintenance equipment and personnel resources" (AFM 66-279, Vol I:2-1). Additionally, CAMS "provides much of the maintenance data needed by major commands, Air Force Logistics Command, Headquarters USAF, and other agencies to manage and track maintenance resources worldwide" (AMF 66-279, Vol I:2-1). Implicit in providing maintenance data is the objective of supplying maintenance decision makers with information that is accurate, timely, and in a format that is easily understood. If any one of these characteristics is missing, then incorrect decisions may result. Consequently, it is valid to consider whether any of these characteristics are missing from the maintenance information collected within the Air Force's maintenance complexes. To begin to address this issue, this research examined the accuracy of information being input into CAMS.

Problem Statement

Aircraft maintenance data must be accurate in order for it to be useful for analysis. Recently, the United States Air Force implemented CAMS as a means, among other things, of collecting maintenance information. It is not clear to what extent CAMS has affected the presence of data inaccuracy previously experienced using the "paper-based" Maintenance Data Collection (MDC) System which CAMS replaced (Folmar:1986). Therefore, there is a continuing need to examine the accuracy of information input into CAMS.

Background

This research is a follow-on to research initiated by Capt Thomas Folmar who investigated, in 1986, "Intentional Input of Errors into the Maintenance Data Collection (MDC) System" (Folmar:1986). His research focused on identifying "the perceived magnitude of intentional errors in the Maintenance Data Collection system database and determining the underlying causes for the reporting of inaccurate and invalid data" (Folmar:4). Although Folmar never formally defined an "intentional error," he implied a definition by stating that his research effort "focused on the possibility that personnel may intentionally input inaccurate and invalid data" (Folmar:5). Additionally, he associated inputting intentional errors with the integrity of personnel inputting the data (Folmar:16-17). Therefore it was felt that Folmar's definition of an "intentional error" was consistent with the

following definition used in this research. An intentional error is one in which the maintenance technician knows the data is incorrect at the time of entry.

Folmar suggested, as a possible cause of intentional errors, that some maintenance technicians lacked integrity, and therefore intentionally falsified data input into the MDC system (Folmar:17-19). However, Folmar also reported that "unintentional errors" were being input into the MDC system by maintenance technicians (Folmar:17). Additionally, Folmar discovered a General Accounting Office Report condemning the poor quality of the information collected in the MDC system (Folmar:14-16). The Air Force response to the GAO report suggested that CAMS would solve many of the problems of the "paper-based" MDC system (Folmar:16). It is clear that CAMS automated the data collection process, but, as with many information systems, it is not clear how CAMS has affected the data collection environment.

Justification

The fundamental reasons to collect maintenance information have remained constant. The information is a resource which maintenance managers use to keep the Air Force capable of performing its mission. The accuracy of maintenance information is affected by many factors, especially the data collection environment. By examining the data collection environment, it may be possible to draw some important conclusions about data inaccuracy. Folmar examined

data inaccuracy under the "paper-based" MDC system, whereas CAMS has "automated" the data collection process. By examining the differences, if any, between these two systems, this research provides insights to the changes in data inaccuracy under the CAMS environment. Also, by identifying the extent, nature and causes of perceptions of data inaccuracies in the CAMS environment, this research lays the foundation for other studies to examine different methods to control data inaccuracy.

Research Objectives

This research had three primary objectives, the first of which concerned the nature, causes, and extent of data inaccuracies being input into CAMS. Additionally, the research examined whether perceptions of data inaccuracies varied across Major Commands (MAJCOMS) and rank structure. Finally the change in data inaccuracy under the CAMS environment was examined by comparing selected results from the first two objective areas of this research to the results obtained by Folmar (Folmar:1986) for users of the MDC system.

Investigative Questions

The following questions were answered in order to acquire the desired understanding of data inaccuracy with respect to the CAMS environment.

1. What percentage of the information being input into CAMS is perceived to be inaccurate?

2. What percentage of the inaccuracies being input into CAMS are intentional? Accidental?
3. What are the possible causes of intentional errors? Accidental errors?
4. How much do the possible causes identified contribute to each type of error?
5. Are the inaccuracies consistent across commands and rank structure?
6. Are the inaccuracies and perceived information value, identified with respect to CAMS, significantly different from the inaccuracies and perceived information value identified by Capt Thomas Folmar (Folmar:1986).

The first investigative question examined the extent of data inaccuracy and investigative question 2 identified the nature of those inaccuracies. Investigative questions 3 and 4 provided a framework to identify the causes of data inaccuracy and determined which of those causes are most prevalent. Investigative question 5 provided the framework to examine numerous factors which could suggest variations in data inaccuracy with respect to CAMS. Investigative question 6 presented a basis for assessing whether the data collection environment improved after CAMS was implemented.

Methodology

Capt Folmar used a survey instrument as a basis for measuring the perspectives of MDC users. Therefore, it was

deemed most appropriate to use a survey instrument to facilitate a valid comparison to Folmar's study. Also, a survey instrument provided the greatest coverage of the population within time and cost constraints. This allowed the results to be more "generalizable" than other methods. Additionally, surveying is an ideal tool to measure the perceptions of others. Finally, it was felt that a survey provided the respondents with anonymity, which lessened their fears of repercussions, and thus increased the response rate.

The survey questions included those used by Folmar to measure intentional errors (Folmar:69-73), but also expanded on his research by quantifying the nature, causes, and extent of accidental errors as well. Additionally, the current research used a two-way Analysis of Variance (ANOVA) to examine whether the responses were consistent across MAJCOMS and rank. Finally, using the appropriate results from Folmar's study and this research, a comparison of the present automated maintenance data collection environment under CAMS and the "paper-based" data collection environment measured in Folmar's research was made using a three-way ANOVA. The ANOVA results served as a basis for determining the changes in data inaccuracy under the CAMS environment.

Scope and Limitations

Folmar's investigation of the causes of data inaccuracy focused primarily on "intentional" errors as a function of the integrity of the technicians inputting the data, but also

identified that "unintentional" or "accidental" errors were occuring as well (Folmar:17). This idea suggested the framework for this review. The current research broadened the perspective of Folmar's initial inquiry by acknowledging that "intentional" errors occur, but further asks: Is the integrity of the technician the primary cause of this type of error, or are there other factors that significantly contribute to the problem? Additionally, this research attempted to specifically identify the causes of "accidental" errors as well.

Since the investigation methodology relied on a survey instrument, this research measured "perceptions" of the accuracy of maintenance data. There is always the possibility that perceptions of reality and reality are different. To confirm this difference field measurements that compare actual maintenance actions performed to those reported could be accomplished. However, such measurements are beyond the scope and capability of this investigation.

Additionally, it was necessary to change some of the survey questions that Folmar used. The acronym "CAMS" replaced the acronym "MDC" in the survey questions. This was considered to be a potential, but minor, source of error in the research. Also, in some cases Folmar had asked "dual" questions. For example, he asked "The majority of inaccurate <u>and</u> invalid data that is input to the MDC system is caused by" (Folmar:70)? It was felt in this research that to ask about both "inaccurate" <u>and</u> "invalid" data confused the

respondent. Therefore only one aspect of the dual questions were asked at a time. This limited the comparisons to Folmar's research and confounded the inferences that could be made. These issues are addressed in greater detail in Chapter 3.

Finally, this research is not meant to support or condemn current maintenance data collection practices, but rather to shed light on the nature of the inaccuracies occurring and further the understanding of the environment which causes these errors.

II. Examination of Relevant Literature

Method of Treatment and Organization

Data entry errors probably result from complicated and interrelated factors. One such factor is the technological or "human factors" problem of transcribing alpha and numeric codes into a computer. A second factor is the motivation of maintenance personnel to correctly accomplish this "administrative" part of their job. To facilitate this research two basic areas of literature were examined. The first is the ergonomics literature that pertains to transcribing alpha and numeric characters from printed lists to keyboards (and similar exercises). Because the technology in this area seems to be mature, the literature available seemed to be old (the latest article identified by this research was written in 1977) and therefore will be presented in a historical sequence. The second area, in the field of "human behavior," pertains to motivation and will be presented by analyzing the relevance of the literature to this research.

Literature Discussion

Ergonomics Technology: Ideal Arrangement of Characters. The earliest prominent article discovered for this review is by John L. Coffey of the Battelle Memorial Institute, Columbus Ohio. In " A comparison of Vertical and Horizontal Arrangements of Alpha-Numeric Material-Experiment 1" (Coffey:93-98), Coffee tries to determine the "relative

effectiveness of visual displays containing alpha-numeric material displayed in vertical and horizontal arrangements" (Coffey:93). He tested several subjects' abilities to quickly and accurately read numbers and digits from strings of digits and alpha characters arranged in various sequences of rows or columns. This experiment measured only the subjects' ability to read information but not to transcribe the information that they read. The major finding of Coffey's experiment was

> the non-significant arrangement of the arrangement variable. It was found that, for all practical purposes, the different effects of vertical and horizontal arrangement of the alpha-numeric materials on operator performance are negligible. (Coffey:98)

Coffey's results were interesting and led others into this area of investigation. C.M. Williams, of Bell Laboratories, conducted a similar experiment that measured the arrangement of horizontal vs. vertical information display. In Williams' experiment "a task was constructed to compare performance on a horizontal to that of a vertical array of 3-digit numbers" (Williams:237). Again, this test measured only the subjects' ability to "locate and mark, as quickly and as accurately as they could, the deviant member within each set of four pairs" (Williams:237). The experiment did not test the subjects' ability to transcribe any information. Williams found that

> The average time required to complete the vertical array was 73 seconds and 44 seconds for the horizontal. The finding that an average of 66% more time was spent on the vertical than on the horizontal array is significant at the .005 level. (Williams:237)

This result is obviously much different from Coffey's results and Williams explains this difference by stating

> Coffey asked direct questions about a single letter, digit, or two-letter word within the array that could have been answered, with the exception of counting, by simply scanning the array until the item was recognized. The subjects were never required to read a series of letters or numbers, yet, the conclusion concerning operator performance implies inclusion of reading as well as recognition tasks. The point to be made is that the conclusion drawn exceeded the limits of the experiment. (Williams:238)

In 1972, Rodney M. Woodward of the North American Rockwell Corporation, Los Angeles Division, decided to investigate the differences between the earlier experiments that examined vertical vs. horizontal arrangement of information. Woodward conducted an experiment that "used a visual comparison of numeric materials to examine the factors of proximity and direction of arrangement, and attempts to reconcile the differences in earlier experiments" (Woodward:337). This experiment required subjects to quickly and accurately pick 3-digit numbers from rows or columns of numbers, then verbally produce the results (Woodward:338). The experiment did not require the subjects to transcribe any information. Woodward's experimental results "support the data, though not all the conclusions, of the earlier studies by Williams (1966) and Coffey (1961)" (Woodward:341). Woodward's final conclusion in this experiment is that there is a difference in whether information is displayed horizontally or vertically, but it is a function of the interaction of proximity and arrangement (Woodward:338).

Ergonomics Technology: Experiments in Transcribing Data. The next series of experiments reviewed concentrates on copying information from one list to another. The first study reviewed, was an experiment accomplished in 1967 by William J. Smith, Jr. titled "Accuracy of Manual Entries in Data-Collection Devices" (Smith:1967). In this experiment, Smith examined the "accuracy of manually recorded messages similar to those encountered in field studies on the accuracy of data collection in production information systems" (Smith:362). He successfully simulated some of the field environment in the laboratory to examine the nature of data entry errors. He classified the types of errors he wanted to identify into three major categories: message format, message content, and event description. During the course of his experiment Smith noted that

> Failure to record events, or omitted entries, proved to be a special concern in both the accuracy of the system and the design of processing techniques. Such inaccuracies are difficult to measure in field studies and awkward to emulate in laboratory tasks. (Smith:363)

Smith's observation has particular relevance to this research. If these types of errors are difficult to measure in field studies and difficult to emulate in the laboratory, then their detection in the "real world" will also be difficult and their impact difficult to assess. In fact, Smith further notes that the only way to detect these types of errors is through "post-processing analysis" (Smith:363). It should be noted that this research did not attempt to identify or quantify this type of error.

In 1977 John N.T. Martin, John Morton, and Pennie Ottley performed an experiment titled "Experiments on Copying Digit Strings." In this experiment they state

> A combination of increasing use of numerical referents for goods and increasing computerization of transactions means that more people have jobs which involve copying lists of relatively meaningless symbols such as numeric codes. When asked to give advice about such situations, either on the design of codes or the layout of the machinery, we keep finding that much of the necessary data is missing from the literature. (Martin et al:409)

The purpose of their experiment was to determine some of the parameters that would help them to answer the designer's questions. They examined such factors as where to locate the input data (above or to the side of a keyboard), whether the data should be in column or row format, and whether using separators (hyphens or spaces) in long digit strings affected the transcription. Their results and conclusions indicate that there was a preference for locating the source of the input data above the keyboard and that there was a definite advantage to using horizontal as opposed to vertical arrangement of the digit strings (Martin et al:416).

Summary of Ergonomics Studies. The earlier research in this area concentrated mainly on recognition of information in vertically or horizontally arranged alpha-numeric sequences. This task was combined in later studies to include transcribing information into computer systems. The research indicates that there is preference for information arranged horizontally, with the source of this information located above the keyboard (Martin et al:416). These studies

are relevant to this research because the maintenance technician is required to transcribe numeric codes from technical manuals into CAMS.

Human Motivation. The second area of examination of this research is aimed at understanding how to motivate maintenance personnel to do their job properly, ie. correctly completing the "administrative" functions of inputting the proper information into CAMS. Indeed, motivating people to do what they should do has always been a dilemma to managers. In the maintenance complex, motivating maintenance personnel to perform their jobs can be quite difficult. Aircraft maintenance is a high pressure job that demands much of people. The "push" to meet flying and training schedules in the Air Force environment focuses most of management's attention on "operational" matters, often to the neglect of "administrative" functions. Additionally, there are no standard procedures for data entry in the CAMS environment. Ideally, each technician should personally enter the information immediately after performing every maintenance action. However, this seldom happens because time and manning constraints are frequently severe. The maintenance technician may have to wait until the end of the day to enter information or may have to give the information to a single person performing data entry for everyone. Obviously, the technicians have many demands with which to contend in addition to entering data on the maintenance actions they performed during the course of the day. Because these

demands and constraints are present in the maintenance technician's world, they have a direct bearing on the data entry environment. To provide a better understanding of this problem, current literature on motivational theory was examined.

There are several theories on what motivates people. One could begin by looking at Maslow's hierarchy of needs (Matteson and Ivancevich:369-389) or Herzberg's motivators and hygiene factors (Daft and Steers:168-169) to explain human motivation. However, there are several reasons these theories do not provide a good framework for this research. First, it can be difficult to locate some individuals on Maslow's hierarchy. Applying Maslow's hierarchy to attempt to find why maintenance technicians do not enter data correctly, if at all, into CAMS would prove quite cumbersome. In addition, some aspects of Herzberg's theory concerning motivators and hygiene factors are inappropriate to explain why maintenance personnel do not enter accurate data. For example, examining how individual promotions are directly affected by maintenance personnel entering correct data into CAMS is meaningless. Therefore, a framework that examines motivation for specific behavior is necessary to examine the CAMS data collection environment. This framework is provided by Expectancy Theory which states that human behavior

> is a function of the value of the reward the doer perceives as coming from the chosen behavior and the doer's expectation that the reward is attainable without undue risk or effort. (Quick:96)

There are several recent studies that relate motivation to perceived reward and required effort to obtain rewards. For example, James R. Bettman, Eric J. Johnson and John W. Payne state, "A major finding of the last decade of decision research is that an individual may use many different kinds of strategies in making a decision contingent upon task demands" (Bettman et al:111). This statement clearly delineates the connection between task effort and strategies for goal attainment. Additionally, they state in their conclusions that "the concept of effort plays a major role in attempts to understand the contingent use of processing strategies" (Bettman et al:134).

Robert J. Graham noted a relationship between data accuracy and personal motivation to enter accurate data. He makes the following observations about computers, their operators, and some faulty common assumptions.

1. Data reflects a constant reality.
2. People are behaving according to the rules.
3. People will do what they say for the reasons they say.
4. Production of data is not affected by organizational politics. (Graham:40-43).

The main point Graham wishes to make by stating the above observations is

> People have motives and purposes and so when they have the ability to influence data they will most likely influence it to suit their purposes. Since all data are produced by people, we can assume that all data are biased. (Graham:43)

Any researcher or person who desires to understand the interaction between the computer system and its human

operators must understand the bias and motives of the human operators (Graham:43).

Conclusion

This research identified a body of literature that provides some understanding of the dual problem of technology and human motivation as it relates to data entry into CAMS, the United States Air Force's maintenance data collection system. Several experiments and articles relating to the human factors aspect of reading and entering data strings into computer systems were identified and presented. Additionally, some articles were identified that addressed human motivation to provide a framework for understanding why humans make some types of decisions. An area of literature that this research was not able to identify was literature that specifically studied all aspects of the maintenance data collection environment at one time. Specifically, in the body of literature that was reviewed, no experiments were conducted that evaluated the interaction between the motivation of operators to enter accurate information and the human factors elements of the environment. The Graham article "touched" on this aspect but did not present any empirical evidence to support his position that all data are biased because of the motives of the human operators that input the data. Therefore, further investigation into the interaction of the motivation of the maintenance technician

and the human factors element of the CAMS environment is warranted.

III. Methodology

Introduction

The purpose of this chapter is to describe the actions that were taken to conduct the research described in chapter one. It explains the reasoning behind the choice of methods and their implementation.

Justification

To answer the investigative questions, a survey instrument was developed. There were several reasons for this choice. First, the survey instrument provided the greatest coverage of the population within time and cost constraints. This allowed the results to be more "generalizable" than other methods. Also, Folmar (1986) used the survey instrument, so it was necessary to replicate this approach to facilitate valid comparisons to his results. Additionally, surveying is an ideal tool to measure the perceptions of others. For example, Emory states "One can seldom learn much about opinions and attitudes except by questioning" (Emory:158). Finally, it was felt that the survey provided respondents with anonymity, which lessened their fears of repercussions, and thus increased both the response rate and the frankness of responses to individual survey items.

Experimental Design

This research uses a "separate sample pretest-post-test design" of the form:

$$
\begin{array}{llll}
R & O_1 & (X) & \\
R & & X & O_2
\end{array}
$$

(Emory:127), where the first observation, O_1, is Folmar's study, the treatment, X, is the CAMS implementation and the final observation, O_2, is this research. "The bracketed treatment (X) is irrelevant to the purpose of the study but is shown to indicate that the experimenter cannot control the treatment" (Emory:127). The samples drawn for Folmar's study and this research were each a stratified random sample of maintenance technicians and managers extracted from the Air Force Manpower and Personnel Center's (AFMPC) ATLAS computer system. Emory states that the separate sample pretest-posttest design is not a strong design because a number of threats to internal validity are not handled adequately (Emory:127). Indeed, in any study threats to internal validity are a concern, but it was of particular interest in this research because the experimenters, Folmar and this author, were not able to control the CAMS implementation. In this research, there were primarily four areas of concern as threats to internal validity (Emory:116) as a result of this experimental design:

History. There may be some historical effects, that is, some event may have occurred between the two samples that confused data inaccuracy. For example, the Air Force's shift to "Rivet Workforce", a workforce compression plan to use maintenance personnel more efficiently, may have caused a shift in the perceptions of data inaccuracy that are not

directly related to the CAMS implementation. However, it was felt that historical factors in this research would be difficult, if not impossible, to control and presented only a minor threat to internal validity.

Maturation. Maturation refers to "changes that take place within the subject which are a function of the passage of time and are not specific to any particular event" (Emory:116). In this research it was possible that the technicians became progressively more computer literate with the passage of time. This may have affected the technicians perceptions of data inaccuracy with respect to CAMS. Again, this aspect of internal validity is difficult to control, and was not considered to be a significant threat to internal validity.

Instrumentation. "This is a threat to internal validity that results from changes between observations, in measuring instrument or observer" (Emory:116). This threat was present in this research. However, steps were taken to minimize the possible impact on this research when the survey questions were developed. These steps are described in detail in the section "Applying the Survey Instrument."

Selection. Emory states "One of the more important threats to internal validity is the differential selection of subjects to be included in experimental and control groups" (Emory:116). This threat was addressed by using random selection in both Folmar's study and this research.

The strongest attribute of the separate sample pretest-post-test design is that "this design is considered to be superior to true experiments in external validity. This strength results from it being a field experiment in which the samples are usually drawn from the population to which we wish to generalize our results" (Emory:127). Generalizing the results of this research to the population of maintenance technicians and managers in the United States Air Force in the CONUS was considered an essential element of this research.

Applying the Survey Instrument

Development of Survey Questions. Most of the survey questions used in this research are adaptations of questions initially posed to maintenance technicians by Capt Folmar. A copy of the survey used in the current research is included as Appendix A. The identical questions could not be used, as would normally be desirable for statistical comparison, because CAMS replaced the "paper-based" Maintenance Data Collection (MDC) system used at the time of Folmar's research. However, CAMS uses the same information elements as the Air Force Technical Order (AFTO) Form 349, the primary paper form used for maintenance data collection at the time of Folmar's research. Therefore, it was desirable to assume that the terms MDC and CAMS are equivalent when used in context of the survey questions. So, to validate the CAMS/MDC equivalence assumption, several maintenance

maintenance technicians and maintenance officers who have experience with both systems were surveyed to evaluate their perceptions of CAMS/MDC equivalence during a survey validation pretest.

Survey Validation and CAMS/MDC Equivalence Results. Six maintenance personnel: three captains, one master sergeant, one technical sergeant, and one staff sergeant, were used to aid in validating the survey used in this research. This is a small number but they were the only personnel locally available, with CAMS experience, to validate the survey. This small number was considered to be offset by the experience level of the personnel. Two of the captains were the CAMS implementation project officers in their respective organizations, and the other four personnel had 12 years combined experience using the CAMS system. Also, 2 of the officers were fellow members of the Graduate of Logistics Management (GLM) Class of 91-S, AFIT, and were therefore cognizant of the concepts of validity under consideration. All of the above personnel had experience with both the CAMS and MDC systems. Additionally, they were told that the survey used in this research was developed from Folmar's survey asking the same or similar questions about the MDC system. After completing the survey used in this research, they were asked "Do you feel the terms CAMS and MDC are equivalent in the context of the survey questions?" all six of the personnel responded that they felt the terms were equivalent.

To support content and construct validity, the pretest group was asked to provide written feedback on each of the questions if they did not understand the question or had suggestions that they thought would improve the quality of the questionnaire. There were several important points that the personnel contributed, and for the most part, the recommendations were incorporated into the survey.

External validity was addressed by the use of a stratified random sample. Emory states "Stratification is also useful when the researcher wants to study the characteristics of certain population subgroups" (Emory:307). By measuring the characteristics of the various strata indicated in this study, the results are more universally applicable to the population of aircraft maintenance technicians and managers as a whole.

Survey Implementation. To provide an understanding of the "degree" of data inaccuracy, the survey questions used interval scales, where possible, to measure the respondents' opinions. This choice was made because, as Emory states, "The interval scale has the powers of nominal and ordinal scales plus one additional strength: It incorporates the concept of equality of interval (the distance between 1 and 2 equals the distance between 3 and 4)" (Emory:91). This concept of equality was necessary for the ANOVA used in this research.

To specifically examine how this research used the survey instrument to explore the causes of data inaccuracy,

each investigative question will be stated, followed by an explanation of survey question development and the statistical analysis used to interpret the survey results.

Investigative Question 1. What percentage of the information input into CAMS is inaccurate?

There are two main constructs in this investigative question. The first is "what is information?" and the second is "what is inaccurate?" In the context of this research, the idea of information was considered to be measured in two dimensions. The first dimension consists of the individual data elements that could be input incorrectly, and the second is the number of transactions that could be input incorrectly. A transaction in CAMS terminology is the transmittal and storage of a "screen" (collection of data elements) of information used by CAMS. This research quantified the percentage of inaccuracies of information occurring only at the data element level. This dimension of the construct of information was used because maintenance personnel are most familiar with the individual data elements that are input into CAMS. The idea of "inaccurate" included any reason the information could be in error. These reasons include maintenance technicians entering the wrong codes because of keystroke errors, lack of time, lack of motivation, difficulty in using the T.O. system, or honest mistakes that the CAMS edit system did not identify. To ensure the maintenance personnel understood that the survey was measuring data inaccuracies at the data element level, an

instruction was provided that explained what a data element was in relation to CAMS.

The percentage of data input into CAMS that is inaccurate was measured in question 13. The respondents were given choices on a scale of 0%-100%, in 10 degree increments, to indicate their opinions. A histogram was used to show the response distribution. The mean, mode, and standard deviation were calculated for each of the demographic groups that participated in the research. The mode of this distribution was the main statistic examined here. This identified the percentage of information input into CAMS, at the data element level, that the greatest number of maintenance personnel felt was inaccurate.

Investigative Question 2. What percentage of the inaccuracies being input to CAMS are intentional? Accidental? This question further examines the nature of the data inaccuracies. Again, there are two constructs of interest; the idea of "intentional" and "accidental" errors. The definition of an intentional error is an error that is input into CAMS by a maintenance technician with full knowledge that they have input erroneous data. Conversely, an accidental error is one that the technician does not know is wrong at the time of data entry. These constructs are best illustrated by examples. Maintenance technicians who input codes that they know will be accepted by the system, but do not accurately reflect the tasks they performed are guilty of intentional errors. A maintenance technician who

unknowingly uses a wrong code because the T.O. system does not clearly indicate which code should be used, demonstrates an accidental error. To ensure the survey respondents understood the definitions of intentional and accidental errors, the definitions were stated in the questions measuring these items.

Survey questions 14 and 15 were used to measure the percentage of intentional and accidental errors respectively. A histogram was used to show the response distribution. The mean, mode, and standard deviation were calculated for each of the demographic groups that participated in the research. The mode of this distribution was the main statistic examined here. The answers to these questions identified the percentage of the total errors occurring in the CAMS system that the greatest number of maintenance personnel felt were attributable to intentional and accidental errors

Investigative Question 3 and 4. What are the possible causes of intentional errors and accidental errors? With respect to CAMS, how much do the possible causes identified contribute to each type of error? There are two directly related constructs in these two questions. The first is the idea of "causes" of intentional and accidental errors and the second concerns the significance of each of the causes. This research considered it impractical, due to the time required to analyze the results, to solicit open-ended opinions of the causes of errors in CAMS. Therefore, specific survey question alternatives were developed using

two sources. The first source was Folmar's research, which identified some probable causes of both intentional and accidental errors (Folmar:46,48). Additionally, the literature on expectancy theory (Quick:96) provided some probable causes that were relevant. In addition, the respondents were given the option to indicate other causes in case the listed causes did not capture the full scope of relevant possibilities. The validity of this process was supported by feedback from the pretest of the survey presented earlier in this chapter.

Survey questions 16-27 measured percentages of intentional and accidental errors attributed to causes indicated in the survey. A histogram was used to show the response distribution for each of the causes presented. The mean, mode, and standard deviation were calculated for each of the causes, and the mean was the main statistic of interest. This indicated which of the causes presented accounts for the largest average percentage of intentional and accidental errors.

Investigative Questions 5. Are the inaccuracies consistent across MAJCOMS and rank structure? This question examined the differences that could occur across the different demographic groups that constitute the population. There are several reasons the identified groups were chosen. First, Folmar used these particular groups and it was desirable to have the same groups used for comparisons in Investigative Question 6. Also, the differences in the

Strategic Air Command's and Tactical Air Command's operating procedures may have had an impact on data inaccuracy. Similarly, the rank structures could have had a significant impact on data inaccuracy. The responses to survey questions 5-27 were examined using a two-way ANOVA to answer this investigative question.

Investigative Question 6. Research Hypothesis: The data input inaccuracies and perceived information value, identified with respect to CAMS, are respectively significantly less and greater than the inaccuracies and perceived information value previously identified by Capt Thomas Folmar. This hypothesis examines how the data collection environment has changed since the CAMS implementation. It is stated to test the anticipated improvement in data inaccuracy and perceived information value under the CAMS data collection environment. It was expected that the inaccuracies identified under the CAMS environment would be less than those Folmar (Folmar:1986) identified and the perceived information value would have improved.

Investigative question 6 was evaluated using a three-way ANOVA. The variables Major Command (MAJCOM), rank, and study were the factors used in the ANOVA. TAC and SAC were the levels used within the MAJCOM factor. Airman Basic (AB) through Staff Sergeant (SSgt) (subgroup 1: "workers"), Technical Sergeant (TSgt) through Chief Master Sergeant (CMSgt) (subgroup 2: "supervisors"), and Second Lieutenant

(2lt) through Colonel (Col) (subgroup 3: "managers") were the levels used within the rank factor. Finally, this research and Folmar's research were the levels used within the study factor. The first two treatments and their appropriate levels were chosen because Folmar used them (Folmar:29) and they are appropriate ways to group the population being studied for the reasons cited above under investigative question 5. The three-way ANOVA compared the means of the responses to questions 5-11 and 14 for this study to the same questions in Folmar's study. The comparison tested for any statistically significant difference between the means of the responses in the two studies while still controlling for the first two factors of MAJCOM and rank. Bonferroni's method (McClave and Benson:865) was used to isolate specifically which means differed significantly.

Sample/Population

Total Population. The population studied was all TAC and SAC military aircraft maintenance personnel in the ranks of airman basic to colonel. At the time of the research, there were a total of 61,270 personnel in this population with 45,073 in the stratum of AB-SSgt (workers), 14,611 in the stratum of TSgt-CMSgt (supervisors), and 1566 in the stratum of 2lt-Col (managers). The total population is presented in Table I. The reason Folmar chose a stratified random sample was that "Stratification is almost always more efficient statistically than simple random sampling and at

worst is equal to it: With the ideal stratification, each stratum is homogeneous internally and heterogeneous with other strata" (Emory:307).

Sample Description. The driving factor of sample size in this research was the restriction that a sample size only large enough to achieve a .10 level of significance could be drawn from the ATLAS database. This is the sample size restriction that is imposed on all surveys distributed to Air Force personnel by the Air Force Manpower and Personnel Center (AFMPC). The following formula was used to compute the sample sizes shown in Table 2 (Folmar:32).

TABLE 1

TOTAL POPULATION.

	SAC	TAC
AB-SSGT	16,550	28,523
TSGT-CMSGT	5,645	8,966
2LT-COL	700	886
TOTALS	22,895	38,375

$$n = \frac{(N \times Z^2 \times 0.25)}{[d^2 \times (N-1)] + (Z^2 \times 0.25)} \qquad (1)$$

where
- n = sample size required
- N = total population size (known or estimated)
- d = level of significance
- Z = Z factor for each level of significance (1.65 for .10 level of significance)

The resulting sample sizes are shown in Table 2.

TABLE 2

SAMPLE SIZE

	SAC	TAC
AB-SSGT	75	75
TSGT-CMSGT	60	60
2LT-COL	60	60
	------	------
TOTALS	195	195

The figures in Table 2 were multiplied by a factor of 2.5 for the stratum of AB-SSgt and 2.0 for the remaining strata to account for survey non-return.

Data Collection Plan

General. The names of the subjects to be surveyed were obtained from the ATLAS database. To limit the number of names extracted from the database and to achieve the randomization desired for this research, the numbers 0-9 were placed in an envelope and drawn 1 at a time at random. The numbers drawn were used to indicate the last digit of the social security number of maintenance personnel to extract from the ATLAS database. Additionally, the search was limited to personnel stationed at Continental United States (CONUS) TAC and SAC Air Force bases. The surveys were mailed to the personnel extracted during the data base search and the respondents were given two weeks from the date of receipt of the survey to respond.

Data Presentation

The data were analyzed using the Statistical Package for the Social Sciences (SPSS) and the SAS System for Elementary Statistical Analysis. The types of statistical analyses used were previously described in the "Applying the Survey Instrument" section. All statistical tests were performed at the .05 level of significance. This level of significance was chosen because equation 1 determines the sample size at the .10 level of significance for proportionate sampling. Since this research did not use proportionate sampling, the formula provided a <u>very</u> conservatively large sample size. Therefore the sample size was sufficient to perform the ANOVA at the .05 level of significance.

IV. Findings

Introduction

The survey questionnaire was mailed to the respondents at CONUS SAC and TAC bases. They were asked to complete the questionnaire and return it within two weeks of the date of receipt. A total of 872 surveys were mailed by 31 May 1991 and, of those returned, most were received by 21 June 1991. Any surveys returned after 28 June 1991 were not included in this survey.

The respondents used a computer optical scanning form to record their answers. These forms were automatically read into AFIT's Academic Computer Support System. The data in this research was analyzed using the SAS statistical software system and is presented in the following tables and graphs.

Demographic Data

The demographic data collected by the survey is presented in Tables 3 and 4.

TABLE 3

RETURN RATE OF SURVEY RESPONDENTS BY MAJCOM

MAJCOM	DISTRIBUTED	RETURNED	PERCENT
TAC	436	180	41.3
SAC	436	191	43.8
TOTALS	872	371	42.5

Although these response rates were less than expected, they were still considered sufficient for generalizing the

TABLE 4

RETURN RATE OF SURVEY BY RANK SUBGROUP

RANK	DISTRIBUTED	RETURNED	PERCENT
	SAC		
Workers	170	52	30.6
Supervisors	133	74	55.6
Managers	133	65	48.8
TOTALS	436	191	43.8
	TAC		
Subgroup 1	170	53	31.2
Subgroup 2	133	65	48.8
Subgroup 3	133	62	46.6
TOTALS	436	180	41.3

Workers = Airman Basic to Staff Sergeant
Supervisors = Technical Sergeant to Chief Master Sergeant
Managers = 2nd Lieutenant to Colonel

responses to the general population, because the sample size given by equation 1 was conservatively large.

Multiple Choice Question Responses

Table 5 reflects the means and standard deviations of the responses for questions 5 through 27 of the current research. Table 6 reflects the results of the two-way ANOVA that identified any statistically significant difference between the means of the class variables (MAJCOM and Rank) of the current research. Table 7 indicates by which level of rank the results were significantly different according to Bonferroni (McClave and Benson:865). There were no significant interactions between MAJCOM and Rank in this ANOVA. It is interesting to note from Table 6 that "rank"

TABLE 5

MEANS AND STANDARD DEVIATIONS OF RESPONSES

Question	N	Mean	Std Dev
Q5	370	2.237	0.866
Q6	369	2.653	0.985
Q7	367	3.414	1.095
Q8	369	2.441	1.046
Q9	370	2.610	1.156
Q10	369	2.300	0.637
Q11	366	3.521	0.958
Q12	359	2.445	1.078
Q13	364	3.697	1.927
Q14	367	3.485	2.429
Q15	368	6.673	3.090
Q16	367	1.910	1.301
Q17	367	3.460	2.019
Q18	366	3.032	1.910
Q19	365	4.556	2.512
Q20	329	2.079	2.129
Q21	364	2.626	1.575
Q22	365	2.408	1.458
Q23	365	3.739	1.884
Q24	364	2.673	1.617
Q25	363	3.396	1.954
Q26	358	2.122	1.530
Q27	319	1.413	1.331

explained most of the statistical difference identified in this current research. From Table 7 it is also notable, for the differences in rank identified, that the supervisors' and the managers' responses tended to be different as well as the managers' and the workers' responses.

Figures 1 through 15 present the distributions of the responses, in the form of histograms, for questions 13-27 of the current research. Survey questions 13-27 attempted to quantify the percentage of inaccurate data, the percentage of total error that was attributed to intentional and accidental causes, and the specific causes of intentional and accidental errors.

TABLE 6

RESPONSES COMPARED BY MAJCOM AND RANK

QUES	SAC	TAC	SG1	SG2	SG3	COMMENT	SIG LEVEL
Q5	2.279	2.191	2.341	2.360	2.008	b	p< .0019
Q6	2.768	2.520	2.631	2.712	2.617	a	p< .0158
Q7	3.421	3.398	3.155	3.468	3.547	b	p< .0166
Q8	2.345	2.537	2.505	2.266	2.563	b	p< .0438
Q9	2.598	2.674	2.476	2.863	2.414	b	p< .0033
Q10	2.288	2.316	2.291	2.345	2.242	c	
Q11	3.489	3.545	3.243	3.338	3.836	b	p< .0001
Q12	2.328	2.579	2.379	2.468	2.344	a	p< .0250
Q13	3.596	3.805	3.845	3.878	3.227	b	p< .0327
Q14	3.421	3.556	3.417	3.971	2.945	b	p< .0030
Q15	6.888	6.390	6.631	6.259	7.000	c	
Q16	1.909	1.915	2.165	1.971	1.609	b	p< .0047
Q17	3.108	3.787	3.282	3.266	3.750	a	p< .0008
Q18	2.892	3.165	3.097	2.950	2.984	c	
Q19	4.476	4.623	4.330	4.770	4.328	c	
Q20	1.959	2.225	2.194	1.950	1.781	c	
Q21	2.494	2.738	2.670	2.446	2.703	c	
Q22	2.343	2.471	2.612	2.367	2.227	c	
Q23	3.447	4.063	3.981	3.813	3.352	a	p< .0014
Q24	2.602	2.746	3.049	2.367	2.617	b	p< .0018
Q25	3.220	3.581	3.194	3.719	3.055	b	p< .0145
Q26	2.000	2.238	2.272	1.828	2.165	b	p< .0499
Q27	1.343	1.493	1.534	1.410	1.156	c	

SG1: workers
SG2: supervisors
SG3: managers
COMMENTS
a: The means differ depending on MAJCOM
b: The means differ depending on Rank Subgroup
c: The means do not differ

TABLE 7

SUMMARY OF DIFFERENCES BY RANK

QUESTION	MAN/WORK	MAN/SUP	WORK/SUP
Q5	*	*	
Q7	*		*
Q8		*	
Q9		*	*
Q11	*	*	
Q13	*	*	
Q14		*	
Q16	*	*	
Q24	*		*
Q25		*	*
Q26	*	*	

* indicates significant difference at .05 level.

Referring to Figure 1, it is evident that the greatest number of maintenance personnel felt that 10% to 30% of the information input to CAMS was inaccurate and, from Figure 2 that 0% to 20% of the total errors were due to intentional causes. However, it is interesting to note from Figure 3 that there was not as much agreement on how much of the total error was due to accidental causes. The modal response for accidental errors" was 90% or more, but there was significant distribution throughout the rest of the percentages.

In attempting to quantify the causes of intentional errors, it is evident from Figure 4 that the greatest number of maintenance personnel felt that only 0% to 10% of the intentional errors were due to pressure to falsify the information. Figure 5 indicates that "lack of adequate time to accurately input information" accounted for 0% to 30% of the intentional errors. Additionally, Figure 6 indicates that the greatest number of maintenance personnel felt that because "personnel do not perceive any benefit from entering accurate information" accounted for another 0% to 30% of the intentional errors. It is clear from Figure 7 that maintenance personnel disagreed on how much of the intentional errors were caused by the "difficulty in entering information into CAMS," but the greatest number felt that it was 10% or more. When the maintenance personnel were asked if there were any causes for intentional errors that were not previously listed, Figure 8 indicates that the respondents felt there were few other causes. Some of the causes that

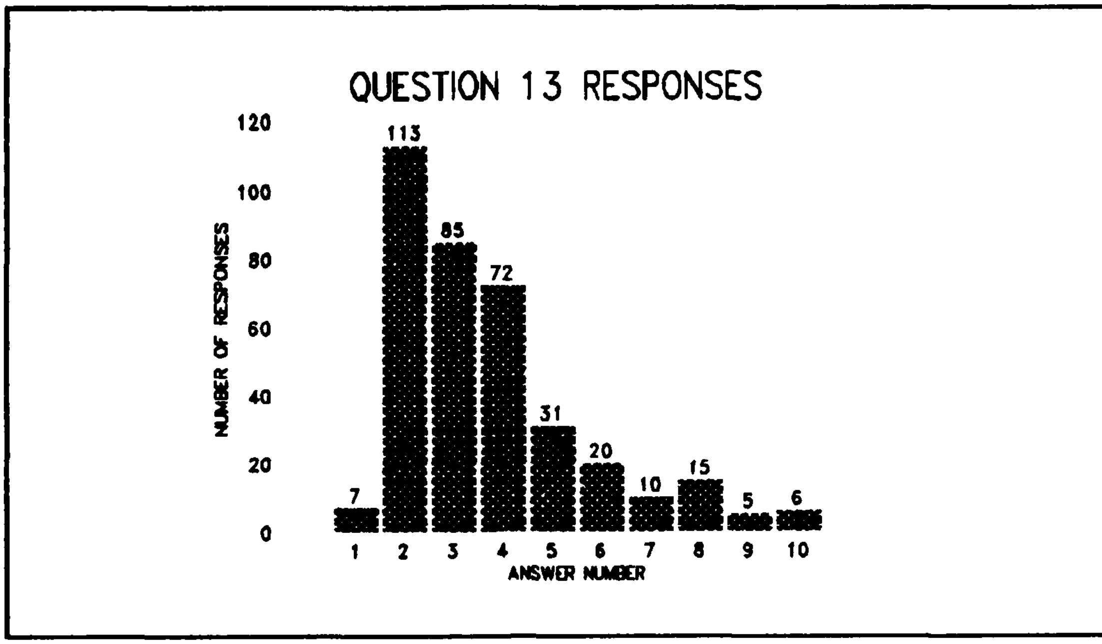

Figure 1. % Inaccurate Data

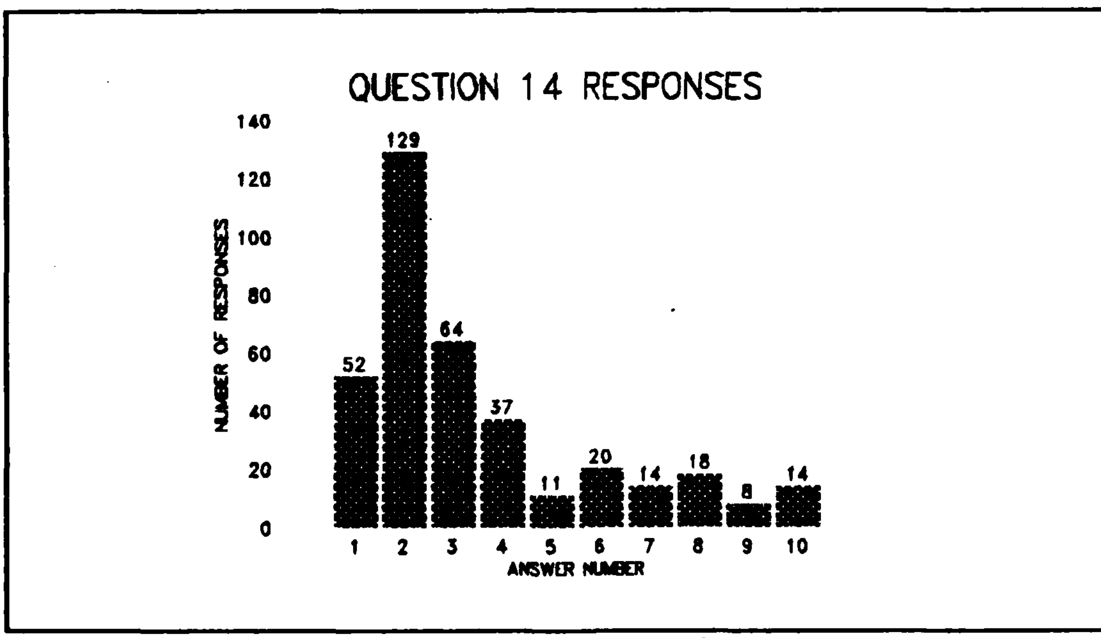

Figure 2. % Intentional Errors

ANSWER	ANSWER	ANSWER	ANSWER
1=0%	4=30%	7=60%	10=90% or more
2=10%	5=40%	8=70%	
3=20%	6=50%	9=80%	

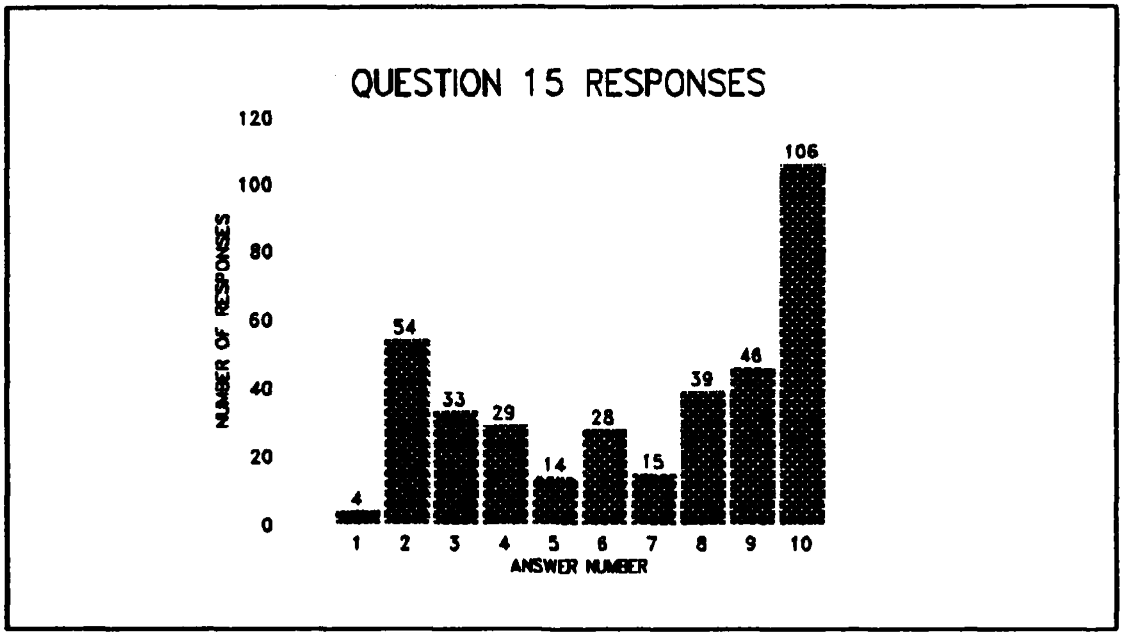

Figure 3. % Accidental Errors

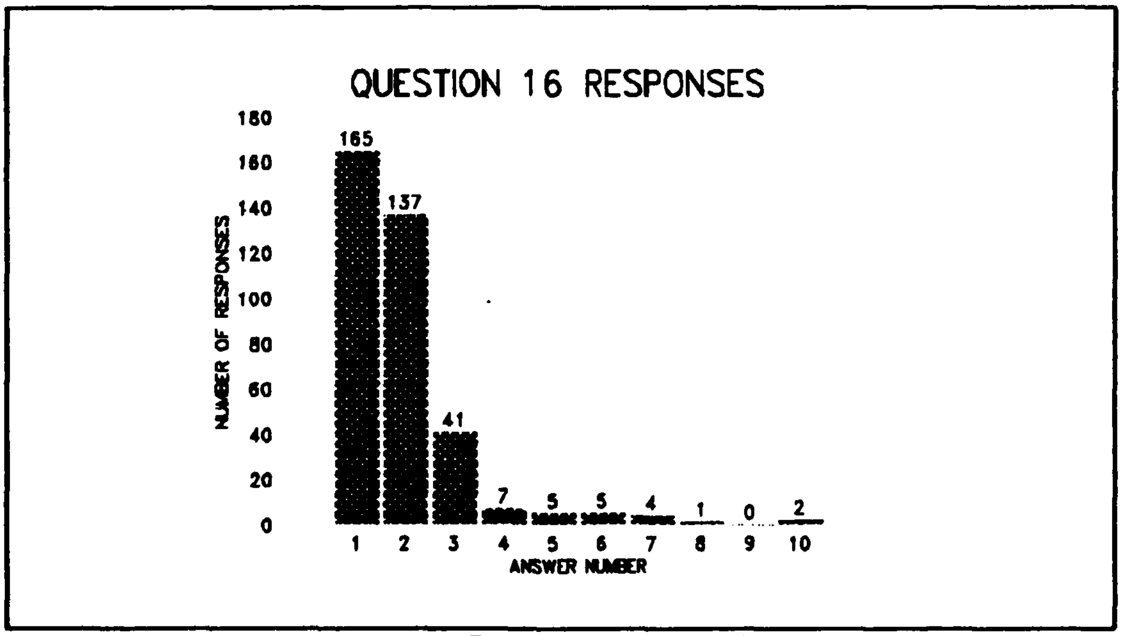

Figure 4. Pressure to Falsify

ANSWER	ANSWER	ANSWER	ANSWER
1=0%	4=30%	7=60%	10=90% or more
2=10%	5=40%	8=70%	
3=20%	6=50%	9=80%	

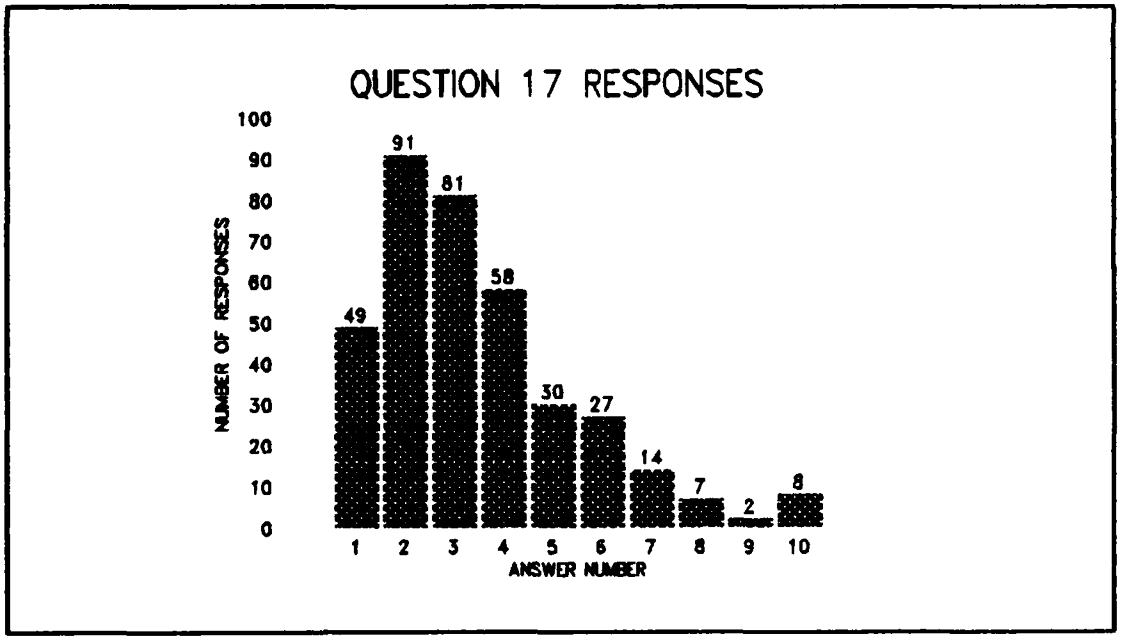

Figure 5. Lack of Adequate Time

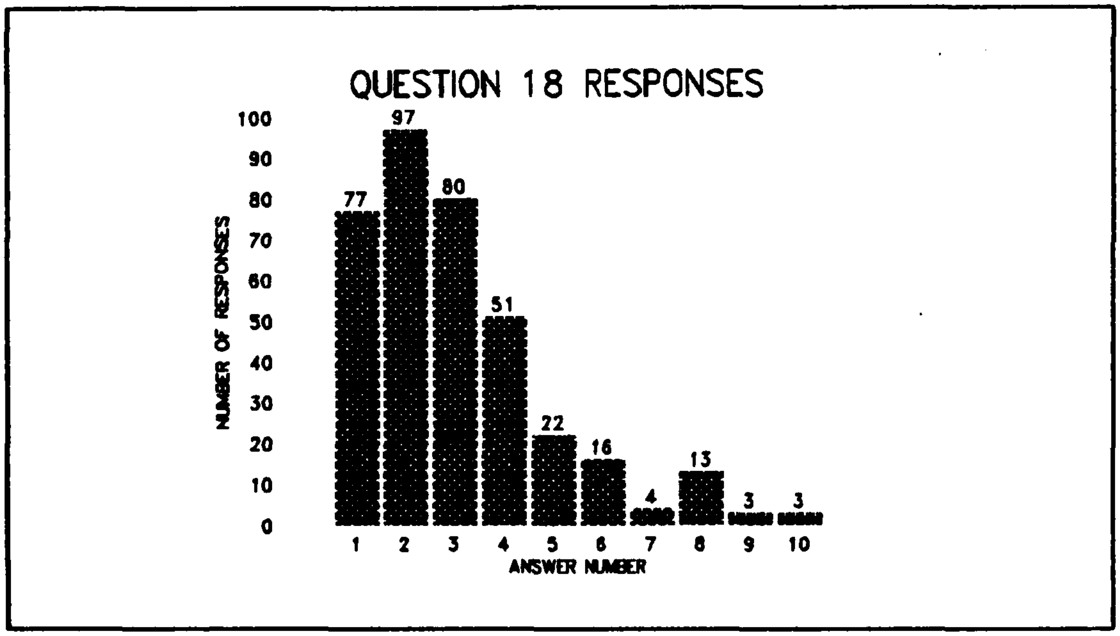

Figure 6. No Perception of Benefit

ANSWER	ANSWER	ANSWER	ANSWER
1=0%	4=30%	7=60%	10=90% or more
2=10%	5=40%	8=70%	
3=20%	6=50%	9=80%	

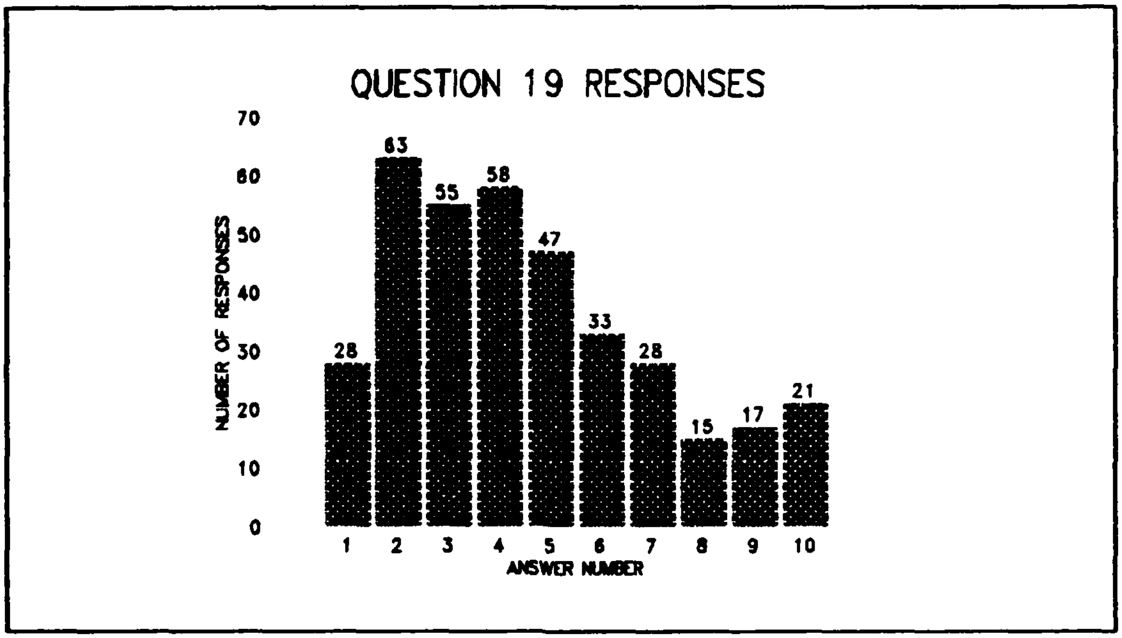

Figure 7. Info Difficult to Enter

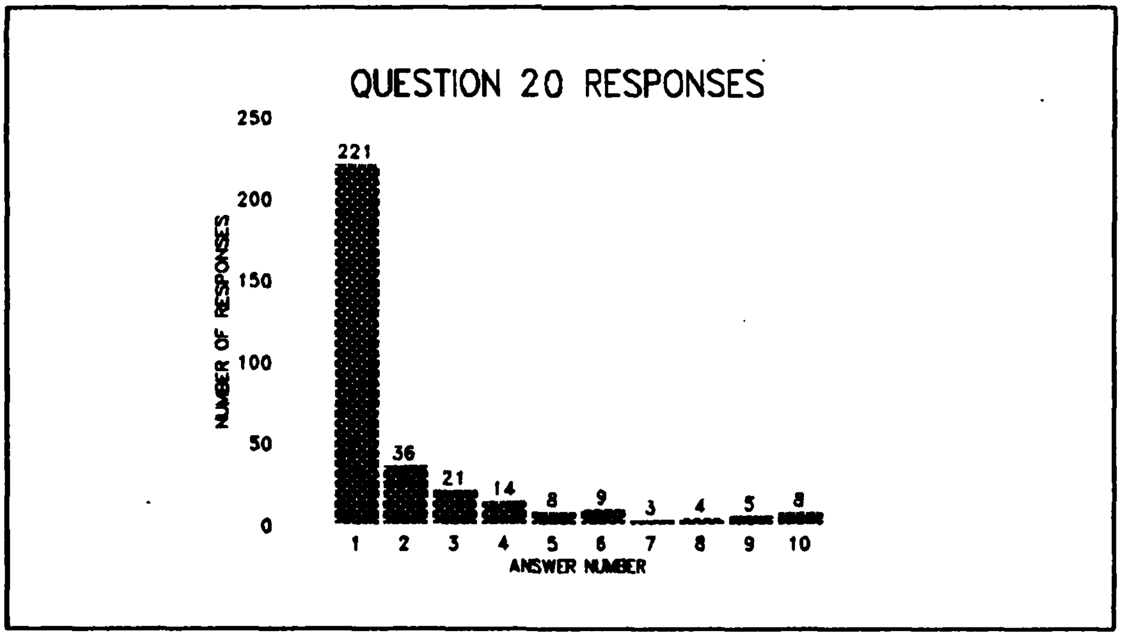

Figure 8. Other Causes of Intentional Errors

ANSWER	ANSWER	ANSWER	ANSWER
1=0%	4=30%	7=60%	10=90% or more
2=10%	5=40%	8=70%	
3=20%	6=50%	9=80%	

the respondents felt were significant, but were not previously listed were that: "CAMS won't accept the correct information so erroneous information is entered to clear the job (15 responses), personnel are lazy and not motivated to enter the correct information (7 responses), and personnel are not adequately trained on CAMS (8 responses). There were several other miscellaneous causes that had five responses or less that are not listed. These may be obtained from the author by request.

Figures 9 through 15 characterize how maintenance personnel perceived the causes of accidental errors. Figure 9 indicates that the greatest number of maintenance personnel identified that keystroke errors accounted for 10% of accidental errors. From Figure 10 it is apparent that another 10% of accidental errors are caused by "insufficient training in using the Technical Order (T.O.) system." A range of 10% to 50% of accidental error was attributed to "insufficient training in using the CAMS system" as indicated in Figure 11. Additionally, it is clear from Figure 12 that the greatest number of maintenance personnel attributed another 10% of accidental errors to "difficulty in finding the correct codes in the T.O. system to input into CAMS." Figure 13 indicates that the greatest number of maintenance personnel attributed 0% to 40% of accidental errors to the "difficulty in using the multiple screens that CAMS requires for data entry." Furthermore, as indicated in Figure 14, another 0% to 10% of accidental error was attributed to

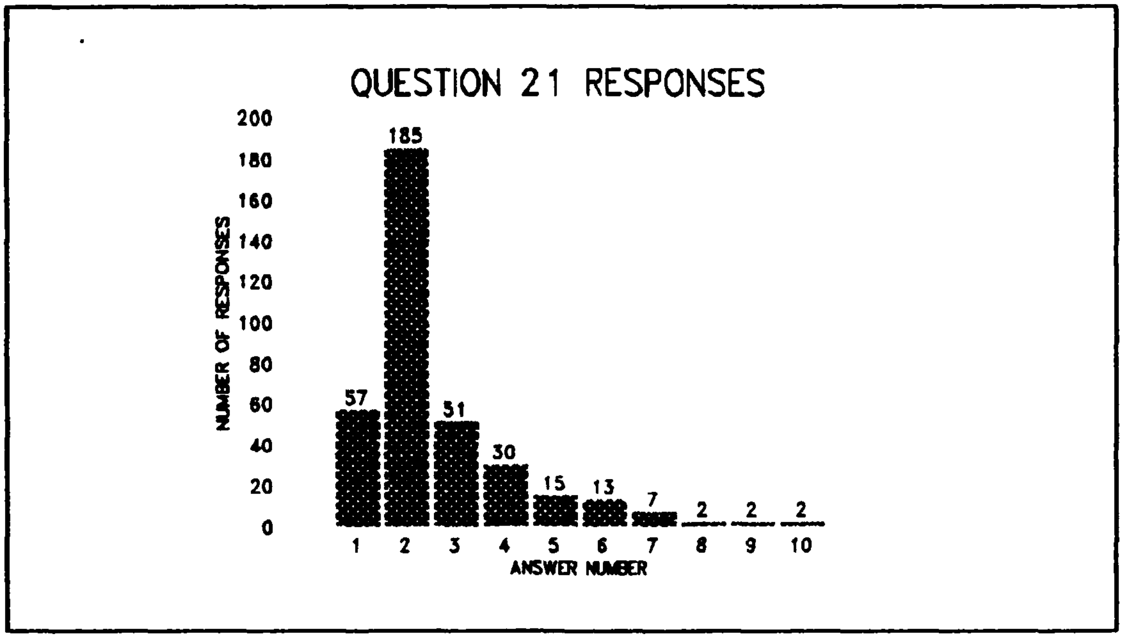

Figure 9. Keystroke Errors

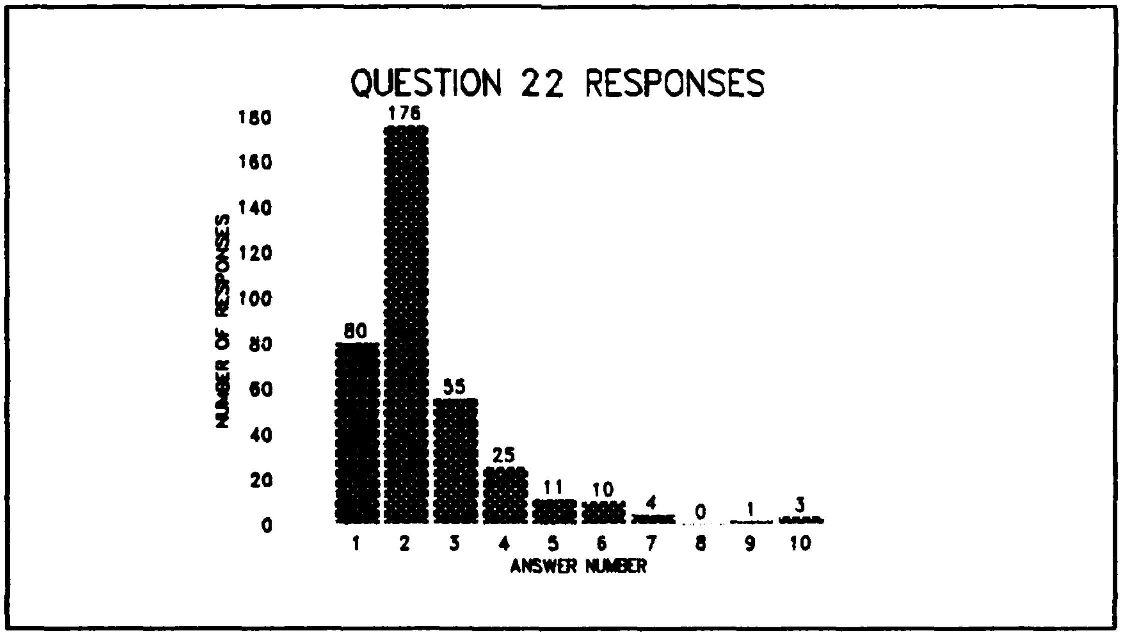

Figure 10. Insufficient Training: T.O. System

ANSWER	ANSWER	ANSWER	ANSWER
1=0%	4=30%	7=60%	10=90% or more
2=10%	5=40%	8=70%	
3=20%	6=50%	9=80%	

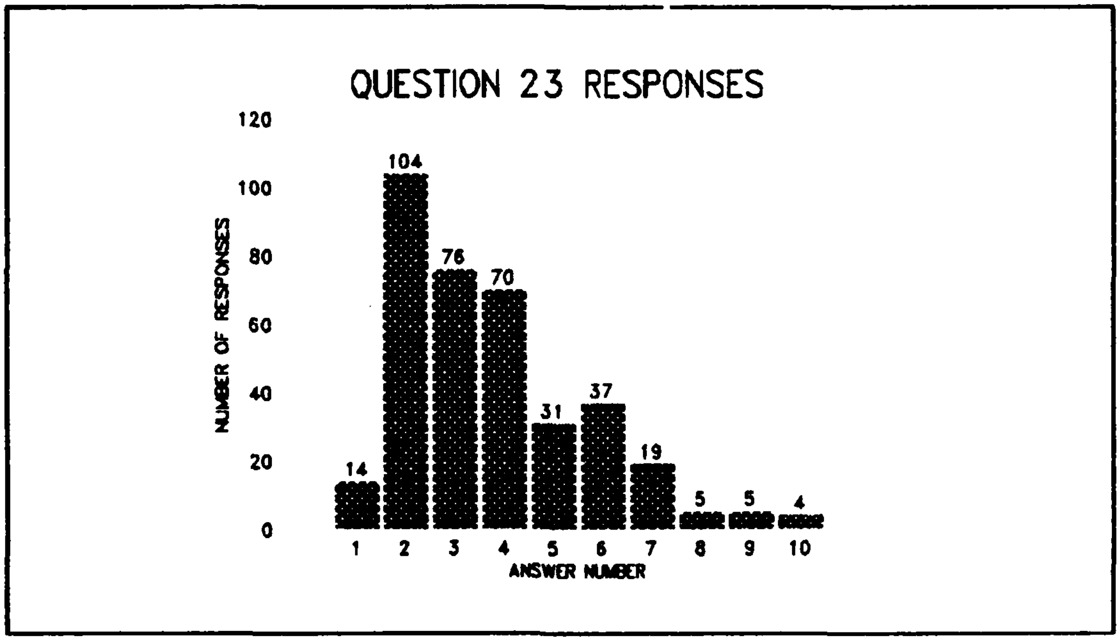

Figure 11. Insufficient Training: CAMS

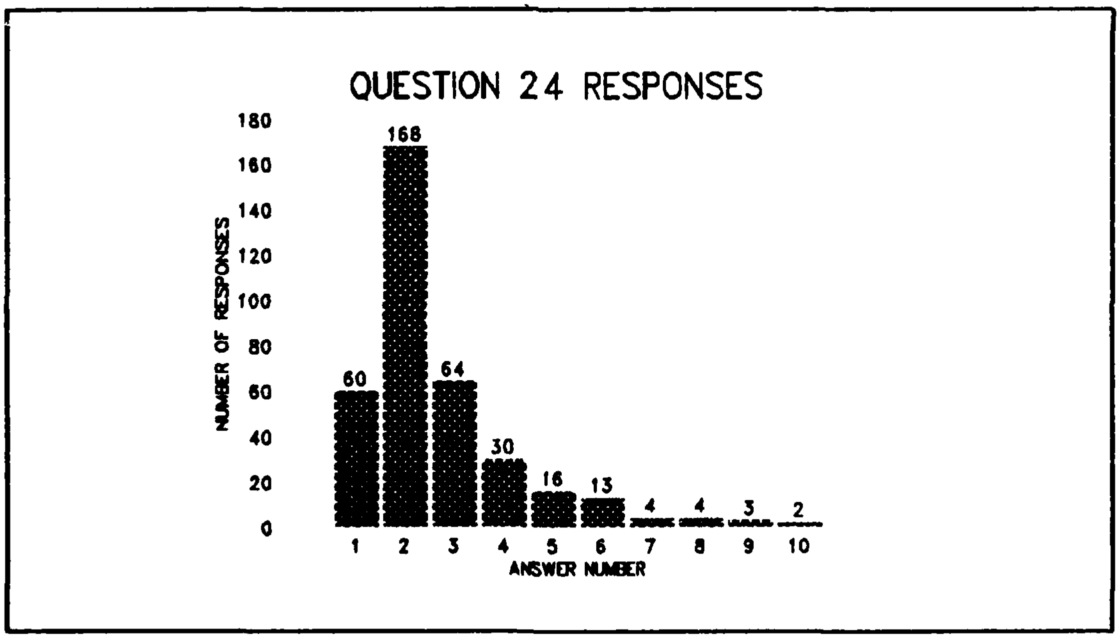

Figure 12. Difficulty in Finding Correct Codes

ANSWER	ANSWER	ANSWER	ANSWER
1=0%	4=30%	7=60%	10=90% or more
2=10%	5=40%	8=70%	
3=20%	6=50%	9=80%	

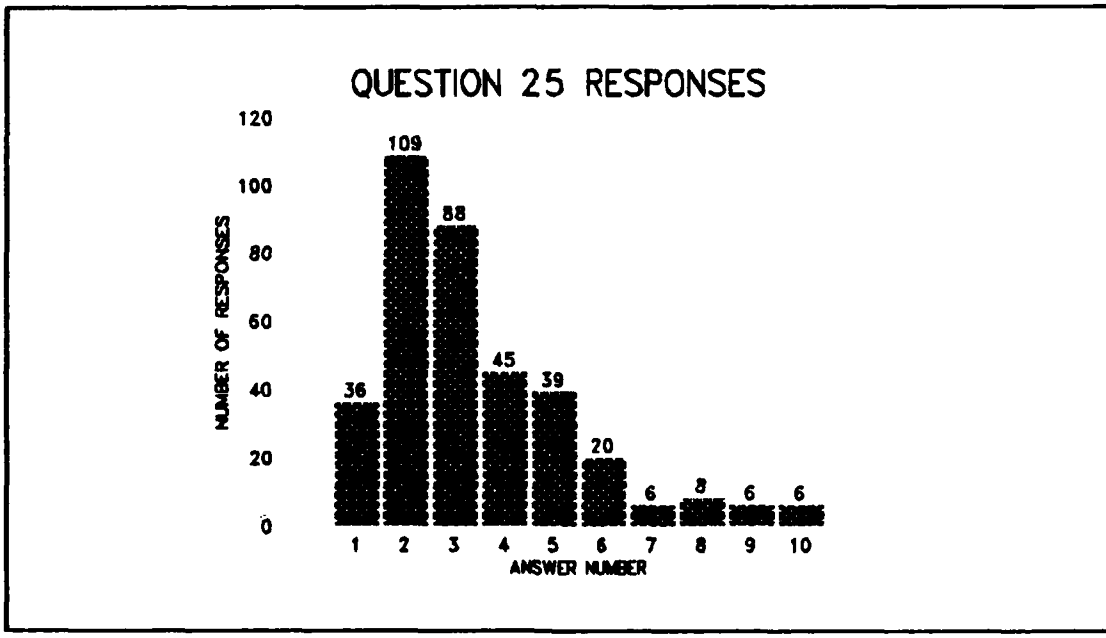

Figure 13. Difficulty in Using Multiple Screens

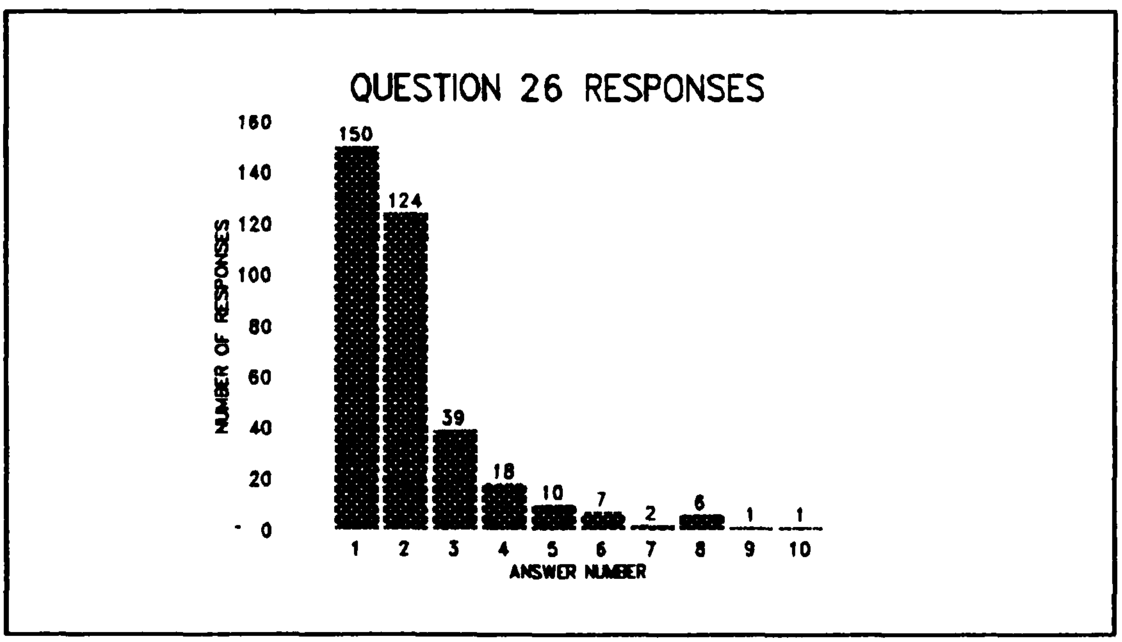

Figure 14. Computer Malfunction

ANSWER	ANSWER	ANSWER	ANSWER
1=0%	4=30%	7=60%	10=90% or more
2=10%	5=40%	8=70%	
3=20%	6=50%	9=80%	

computer malfunction. Finally, as seen in Figure 15, very few maintenance personnel indicated that there were other reasons not previously listed for causes of accidental errors. There were no consistant responses among the reasons cited by the respondents in this "other" category.

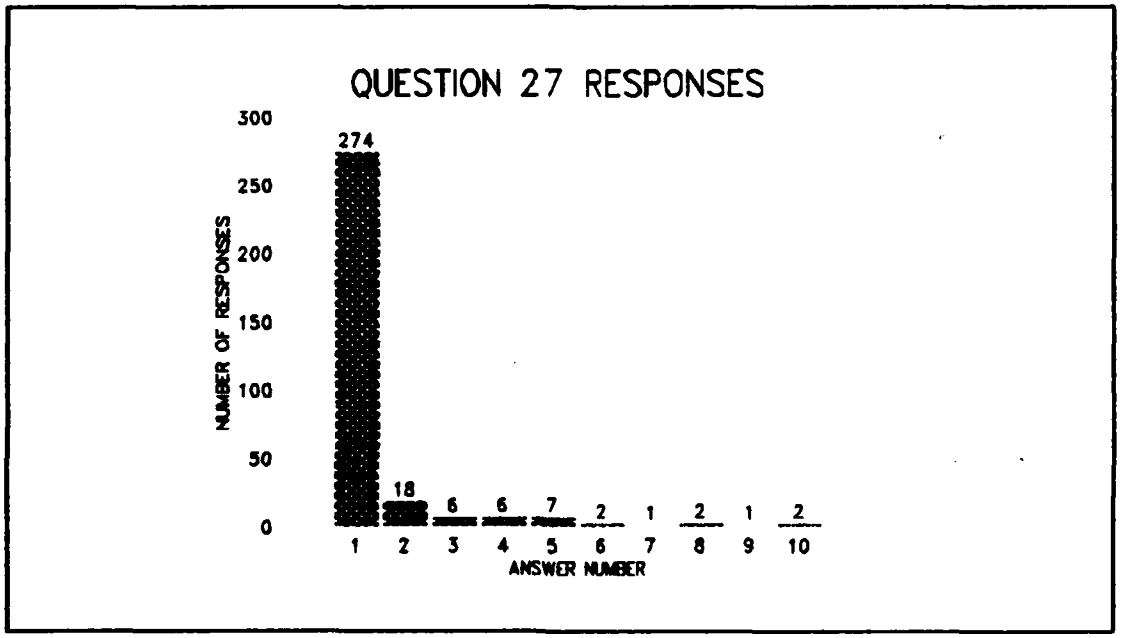

Figure 15. Other Reasons for Accidental Errors

ANSWER	ANSWER	ANSWER	ANSWER
1=0%	4=30%	7=60%	10=90% or more
2=10%	5=40%	8=70%	
3=20%	6=50%	9=80%	

<u>Open Ended Question Responses</u>

The open ended questions were asked to further the understanding of the causes of errors and to determine what, if anything, could help to make the CAMS environment less prone to errors. The responses to these questions were "categorized" and summarized in Figures 16 through 20. In

the following presentation of these results, only the top 3 categories for each question will be discussed and the remainder are included for inspection in appendix C.

Question 28 asked "If it were in your power to change the CAMS system what changes would you make and why?" The three ways in which the greatest number of maintenance technicians said that they would change were to: make CAMS more user friendly (1), eliminate/reduce the number of multiple screen entries (2), and decrease CAMS downtime (3).

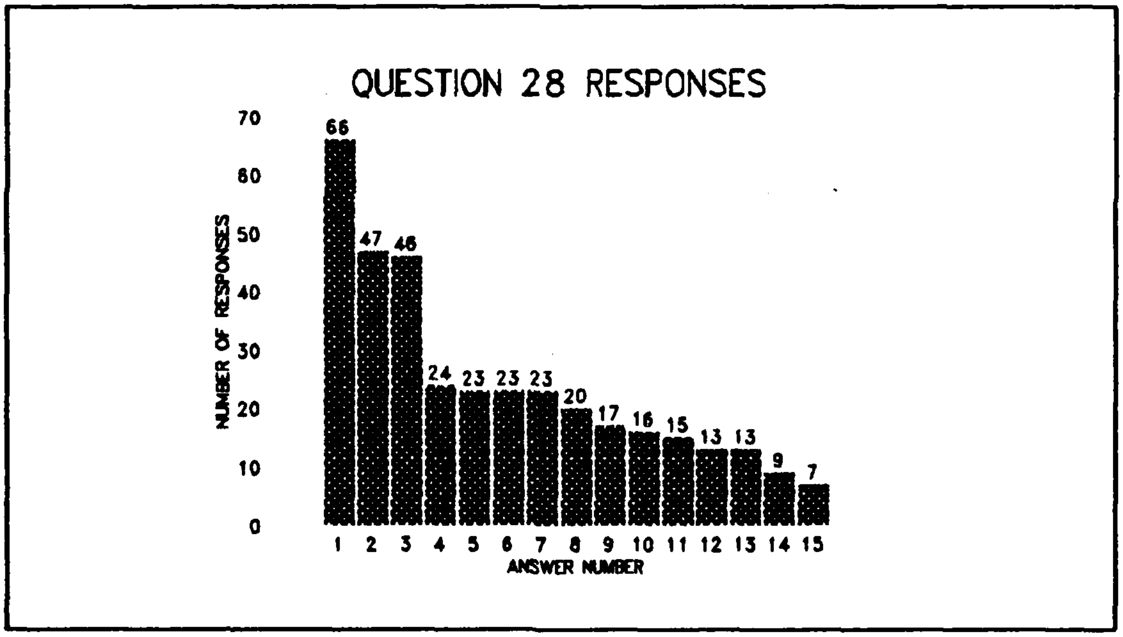

Figure 16. Question 28 Responses

Question 29 asked "What do you feel is the single most prevalent reason for errors occurring in the CAMS database?" The top 3 items that the greatest number of maintenance personnel cited for these errors were: inadequate training on the CAMS system (1), personnel are not motivated to make the

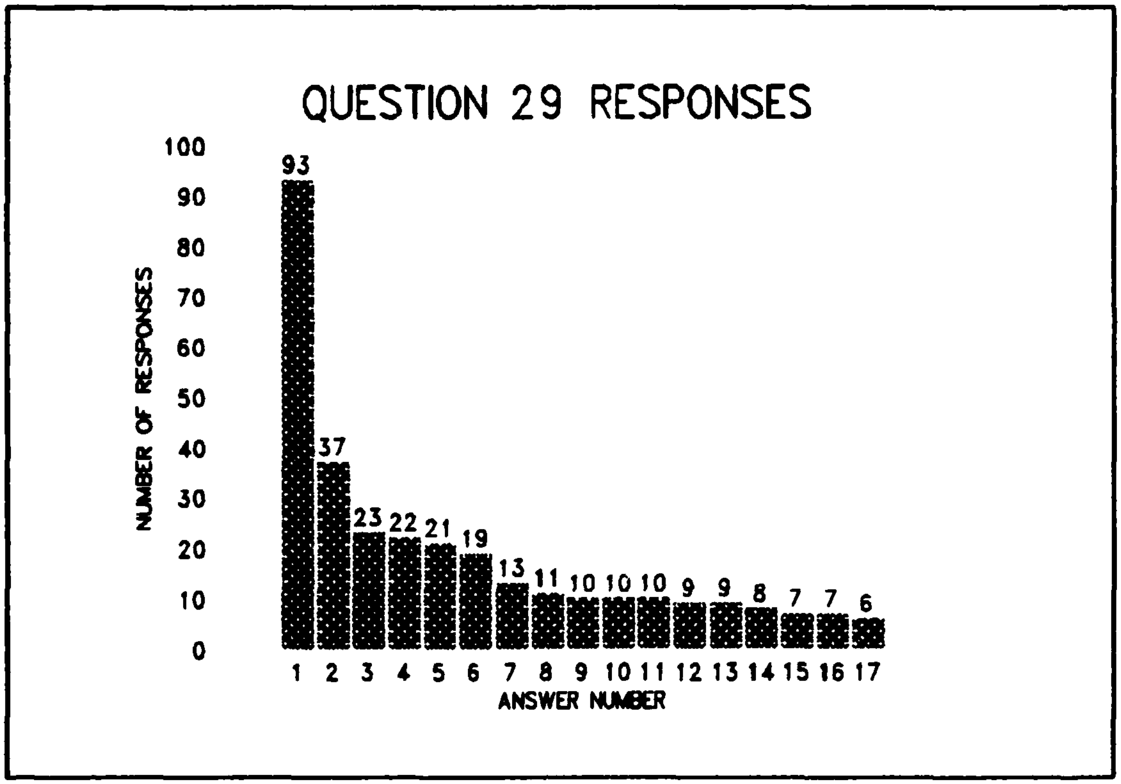

Figure 17. Question 29 Responses

correct entries (2), and CAMS is not user friendly (3). It is interesting to note from Figure 17 that inadequate training is by far the largest contributor cited by the maintenance personnel.

Question 30 asked "What type of data concerning maintenance actions are most often reported in error?" The top 3 items cited by maintenance personnel for these errors were: work unit codes (1), action taken codes (2) and how malfunctioned codes (3).

Question 31 asked "If you know any person(s) who intentionally inputs false data into the CAMS system, what are the top three most common reasons given for their

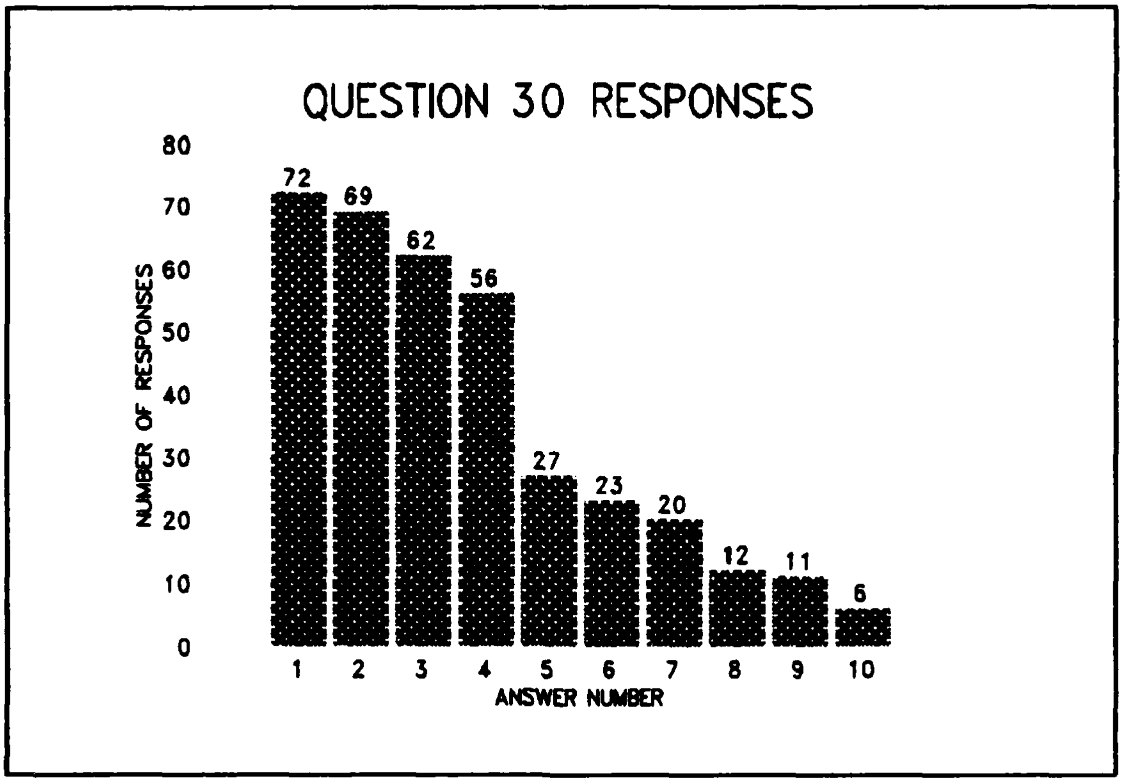

Figure 18. Question 30 Responses

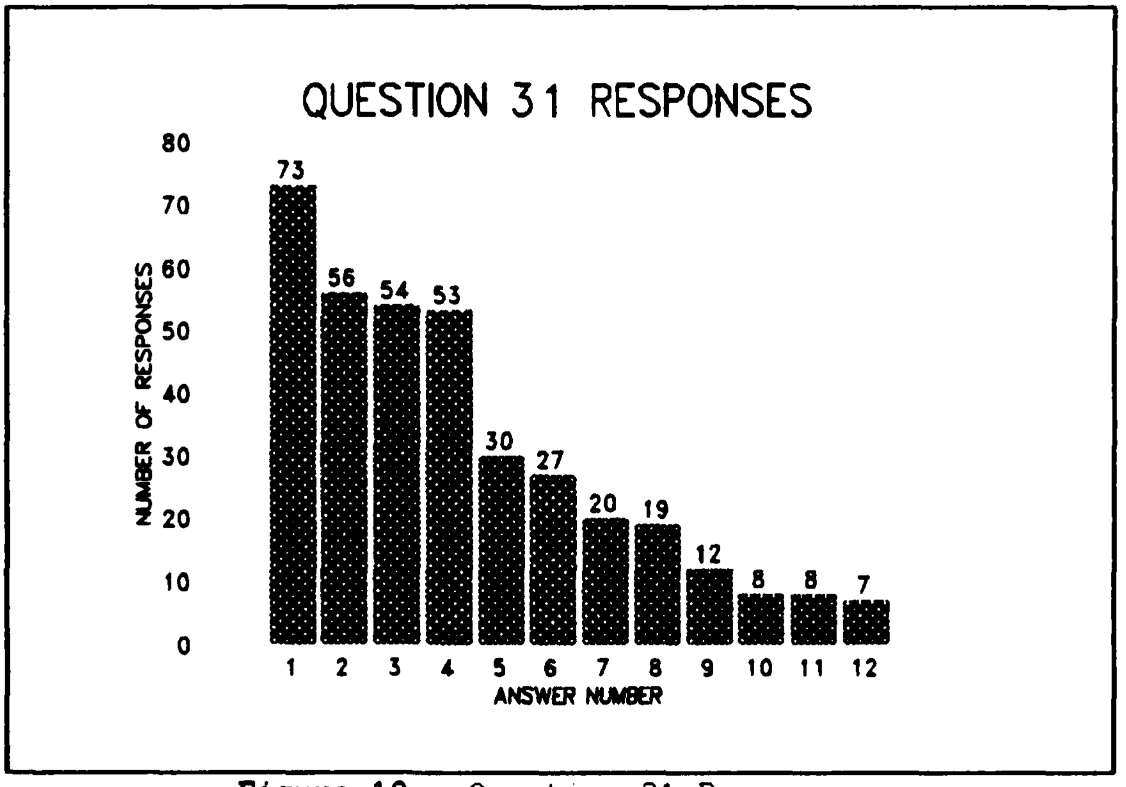

Figure 19. Question 31 Responses

actions?" The top 3 reasons cited by maintenance personnel were: CAMS won't accept the correct information, so something was entered to clear the job (1); insufficient time to make the correct entries (2); and I don't know anyone who intentionally inputs incorrect information (3).

Question 32 asked "In your opinion, what is the single most beneficial action we could take to reduce or eliminate data entry errors in CAMS?" The top 3 recommendations the maintenance personnel made were to: provide training on the CAMS system (1), make CAMS more user friendly (2), and include on line help capability within the CAMS system (3).

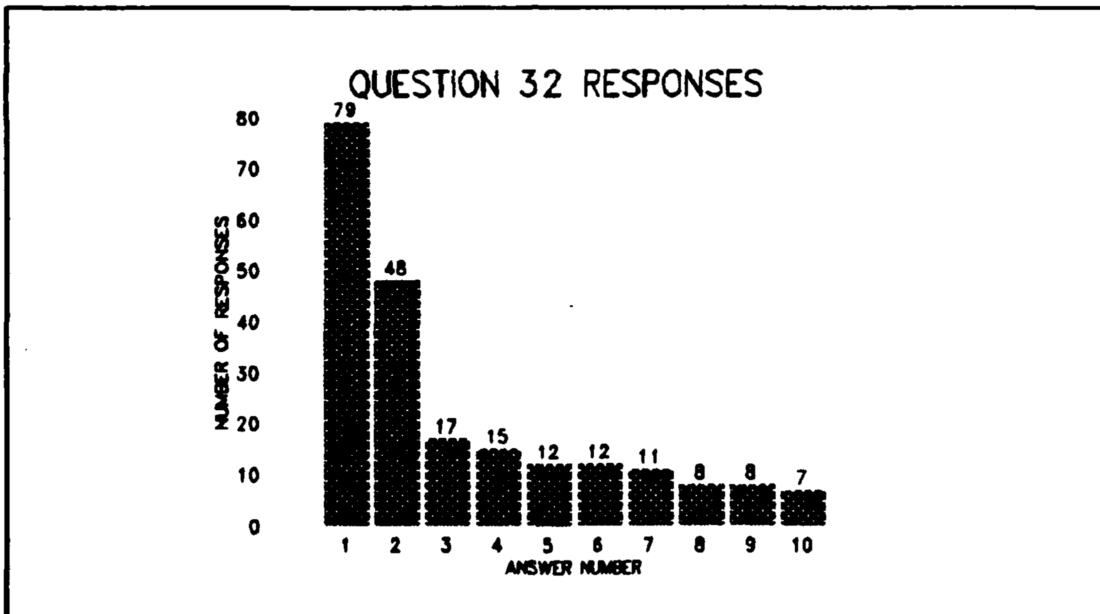

Figure 20. Question 32 Responses

Comparison of Current Research to Folmar's Research

Responses to questions 5-11 and 14 were used to directly compare present perceptions of data inaccuracy under the CAMS

environment to those experienced under MDC (Folmar:1986). The scales for these questions are restated here for reference in the following results. Questions 5-9 used a Likert scale ranging from one to five with one representing the response "strongly agree" and five representing the response "strongly disagree."

The results of the three-way ANOVA for questions 5 through 11 and 14 indicated there were several significant interactions occurring. An approach to analyzing these interactions was obtained from the literature (Milliken and Johnson:198-199) and applied to the results of the ANOVA. These interactions are summarized in Table 8 and illustrated in Figures 21 through 27. The only question that did not have a significant interaction term was question 7. This is the only question where the main effects will be discussed.

TABLE 8

SUMMARY OF SIGNIFICANT INTERACTIONS

QUESTION	INTERACTIVE TERM	SIGNIFICANCE
5	Rank*Study	$p < .0015$
6	Rank*Study	$p < .0083$
7	None	None
8	Rank*Study	$p < .0463$
9	Rank*Study	$p < .0143$
10	Rank*Study	$p < .0354$
11	Rank*Study	$p < .0001$
14	Rank*Study	$p < .0001$

Note: Tests conducted at the .05 level of significance.

Question 5 examined the perception of "valuable information" provided under both the CAMS and MDC

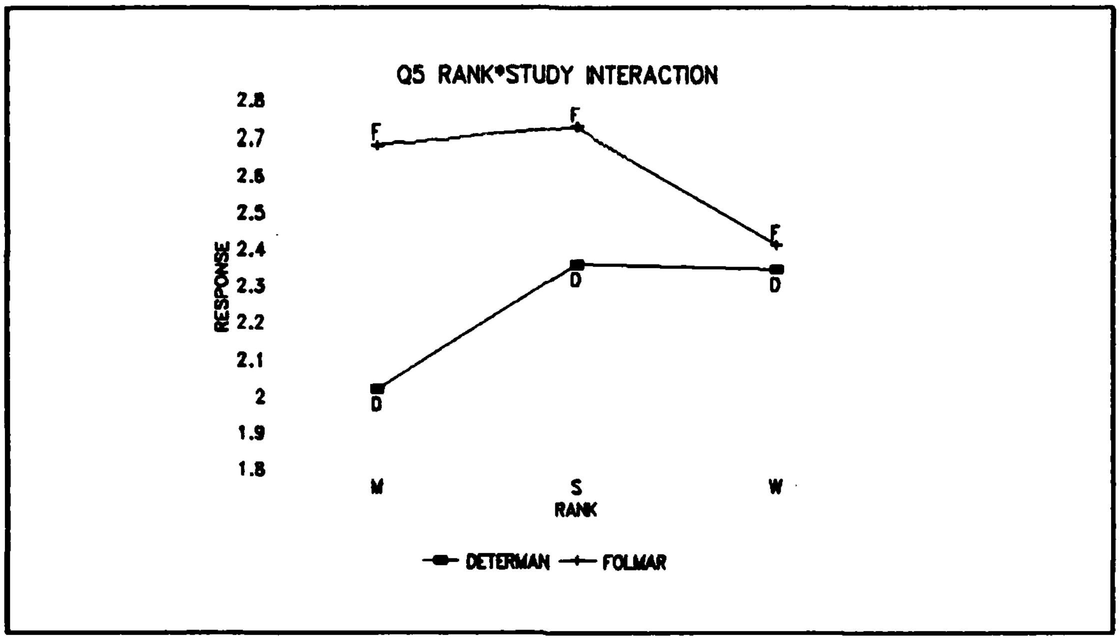

Figure 21. Q5 Rank*Study Interaction

environments. Since there was interaction between the variables of rank and study in the analysis of this question the main effects between command, rank and study will not be discussed. Figure 5 displays the interaction between the variables of rank and study. In this particular case, there is no statistically significant difference between the two studies at the worker level ($p < .5746$). However, at the manager (M) and Supervisor (S) levels there is an improvement (recall that the further toward the response "one" the more in agreement the respondent was with the statement.) in the perceived value of information provided by CAMS over MDC.

Question 6 examined the perception of "timely feedback" under the CAMS and MDC environments. Again the ANOVA revealed interaction between the variables of rank and study. Figure 22 shows this interaction. At the manager and

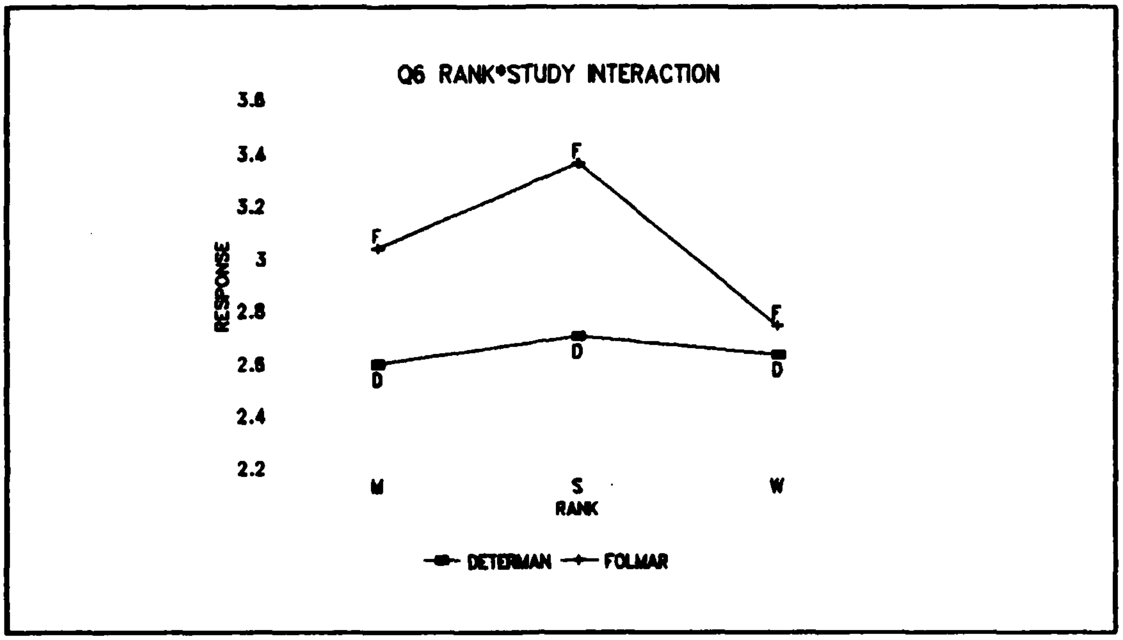

Figure 22. Q6 Rank*Study Interaction

supervisor levels, there is improvement by CAMS over the MDC system ($p<.0002$ and $p<.0001$ respectively), while at the worker level there was no difference ($p<.4037$).

Question 7 compared the perception of the ability to provide accurate accounting of manhour utilization under the CAMS and MDC environments. This was the only comparison in this study that significant interaction effects were not observed. The perception measured under MDC (Folmar:1986) produced a mean of 3.636 and the perception measured in this research produced a mean of 3.408. This result was statistically significant at $p<.0018$. Although this is an apparent improvement in manhour accounting under the CAMS environment, maintenance personnel under both systems tended to disagree with the statement that the respective systems provided accurate manhour accounting. This perception was consistent across MAJCOM, rank, and study.

Question 8 measured the perception that inaccurate data is input to the system because of the difficulty in coding the information under the respective CAMS or MDC environment. The ANOVA revealed interaction between the rank and study variables. Figure 23 shows the result of the interaction. At the supervisor level, the perception increased under the CAMS environment (p<.0002) while at the manager and worker levels, the perception has not significantly changed.

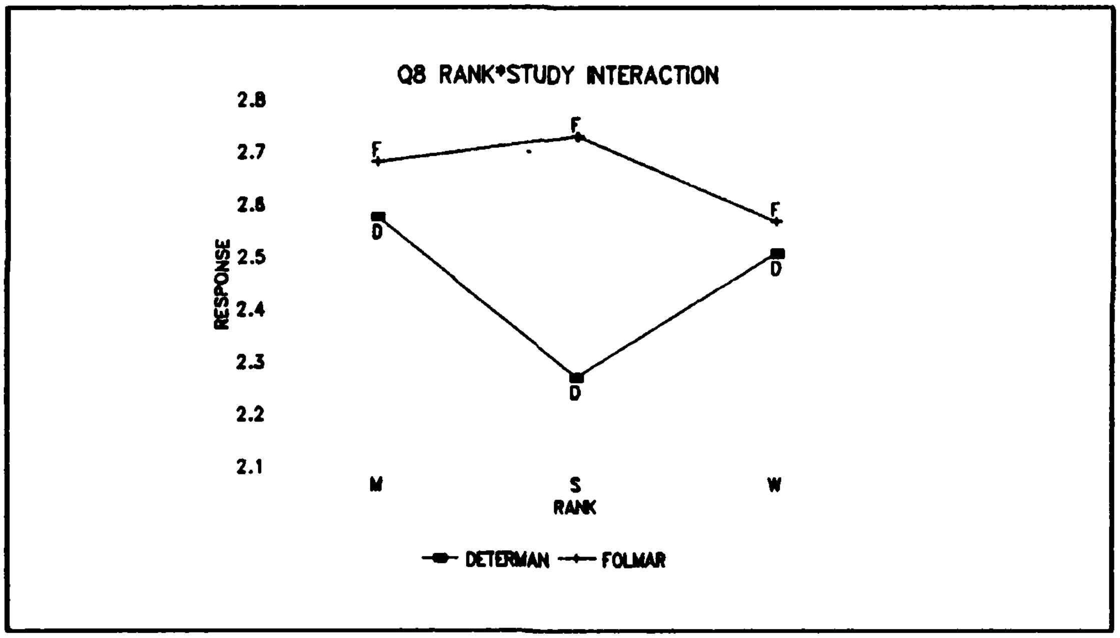

Figure 23. Q8 Rank*Study Interaction

Question 9 evaluated the perception that the system (CAMS or MDC) was a valuable management tool which the Air Force should retain. Once more the ANOVA revealed interaction between the rank and study variables. Figure 24 shows the results of this interaction. The perception improved at the manager level (p<.0001) but did not improve

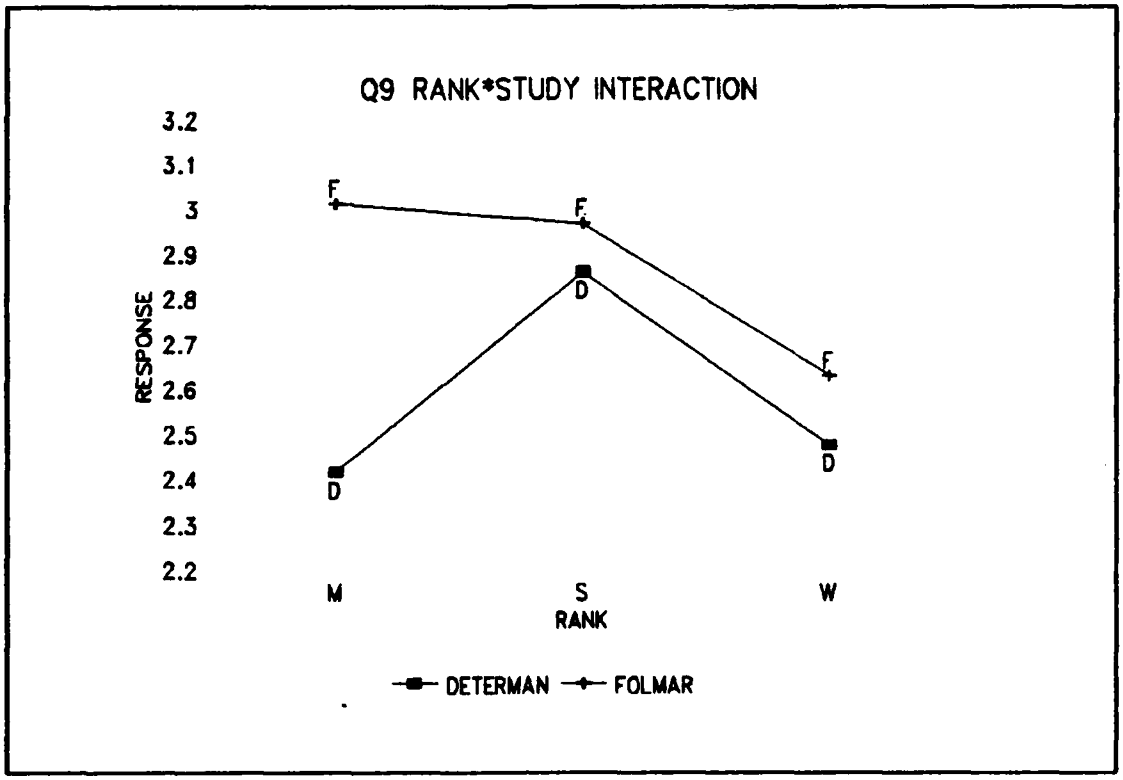

Figure 24. Q9 Rank*Study Interaction

at the supervisor or worker levels ($p < .4061$ and $p < .2860$ respectively).

Questions 10 and 11 used a Likert scale ranging from one to five with one representing the response "always" and five representing the response "never."

Question 10 evaluated the perception that correct data is input in the system (CAMS or MDC). Again, there was interaction identified between the variables of rank and study. Figure 25 shows this interaction. At the manager and supervisor levels there is an improvement under the CAMS environment ($p < .0001$ and $p < .0011$ respectively) but there was no improvement at the worker level ($p < .5224$).

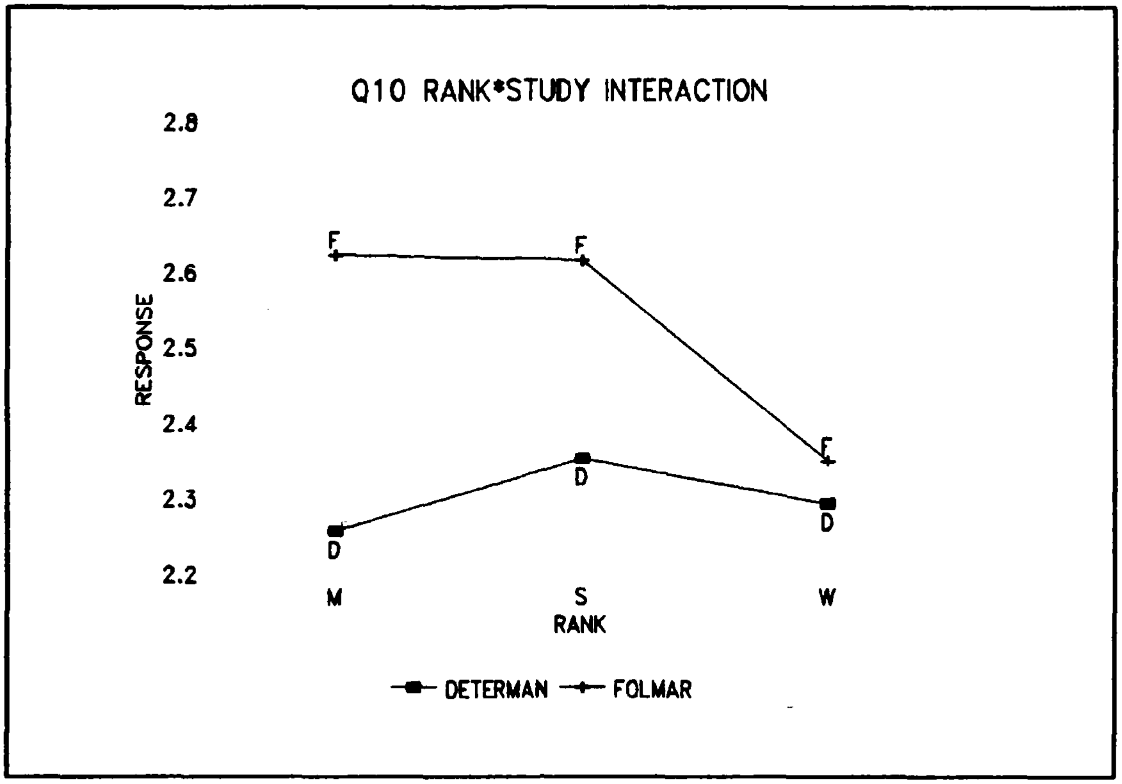

Figure 25. Q10 Rank*Study Interaction

Question 11 evaluated the perception that maintenance personnel are pressured by superiors to manipulate the data input to the system (CAMS or MDC). The ANOVA identified significant interactions between the rank and study variables once more. This interaction is shown in Figure 26. There was an improvement in perception at the manager level ($p<.0001$) but there was no significant difference at the supervisor or worker levels ($p<.3111$ and $p.2418$ respectively).

Question 14 measured the perception of the percentage of <u>inaccurate</u> information that was input into the system (CAMS or MDC) by using a scale from one to ten representing percentages from 0% to 90% or more respectively. The ANOVA

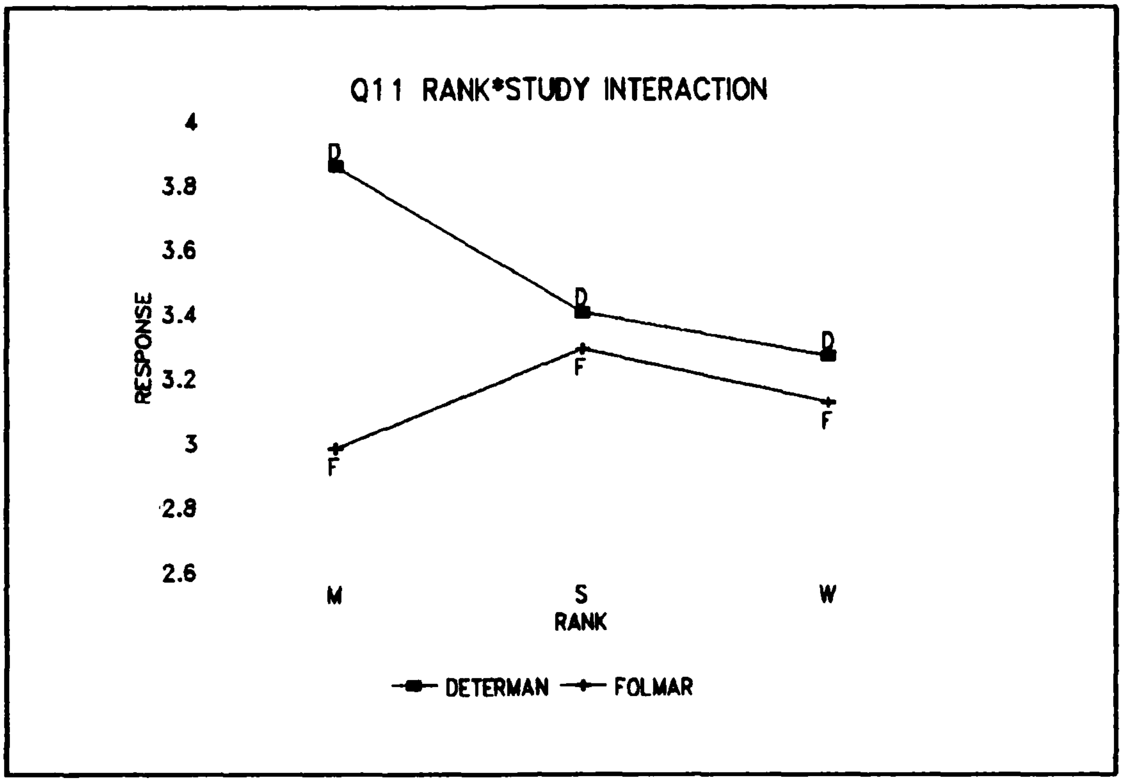

Figure 26. Q11 Rank*Study Interaction

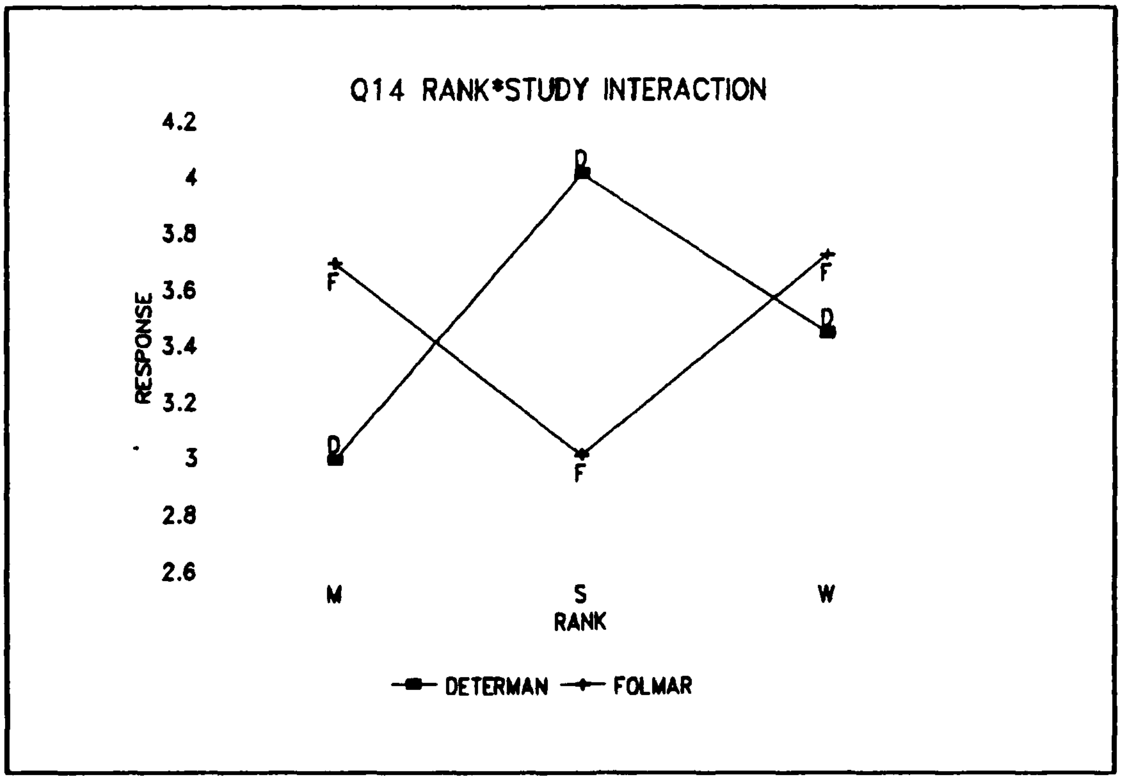

Figure 27. Q14 Rank*Study Interaction

identified interaction between the rank and study variables. This interaction is shown in Figure 27. Supervisors perceived that inaccurate information had increased under the CAMS environment ($p<.0004$), while at the manager level, the perception of inaccuracy had decreased under the CAMS environment ($p<.0133$). The perception at the worker level was not significantly different ($p<.3727$).

Summary

The results presented in this chapter characterized the nature, extent and causes of data inaccuracy under the CAMS environment. Additionally, the results indicate that the rank of maintenance personnel influences their perception of data inaccuracy. Also, the maintenance personnel indicated that the largest contributor to data inaccuracy was lack of training on the CAMS system and that a training program could aid in reducing data inaccuracy. Finally, the results indicate that, in general, there was perceived improvement in data accuracy under the CAMS environment at the manager and supervisor levels, but not at the worker level.

V. Analysis, Conclusions, and Recommendations

Meeting the Research Objectives

This research fulfilled the three primary objectives stated in Chapter 1. It examined the extent, nature, and causes of data inaccuracies being input into CAMS. Additionally, it examined whether perceptions of data inaccuracies varied across MAJCOMS and rank structure. Finally, it examined the changes, if any, in the perception of data inaccuracy under the CAMS environment when compared to the previous MDC environment (Folmar:1986). By restating the research objectives here, a logical framework is provided to analyze the results obtained in this research.

First Objective. The research identified the extent, nature, and causes of data inaccuracies being input into CAMS. To accomplish this analysis, the means introduced in Table 5 of Chapter 4 were converted to the percentages corresponding to the scale used in the particular survey questions. For example, in question 14 a mean of 3.485 was reported. This translates to an approximate mean of 25%. These percentages were used in the following analysis to supplement the modal analysis. The modal responses and percentages for each question are summarized in Tables 9 and 10.

The results from survey question 13 were used to examine the "extent" of data inaccuracy under the CAMS environment.

TABLE 9

SUMMARY OF
THE NATURE OF DATA INACCURACY
IN THE CAMS ENVIRONMENT

QUESTION	NATURE	MODE(%)	MEAN(%)
Q13	% Inaccurate Info	10	27
Q14	% Intentional Errors	10	25
Q15	% Accidental Errors	90	57

TABLE 10

SUMMARY OF
THE CAUSES OF DATA INACCURACY
IN THE CAMS ENVIRONMENT

QUESTION	CAUSE	MODE(%)	MEAN(%)
	INTENTIONAL ERRORS		
Q16	Pressure to Falsify	0	9
Q17	Lack of Time	10	25
Q18	No Perception of Benefit	10	20
Q19	Difficulty in Entering the Data	10	36
Q20	Other Causes	0	11
Totals		30	101
	ACCIDENTAL ERRORS		
Q21	Keystroke Errors	10	16
Q22	Insufficient Training: T.O. System	10	14
Q23	Insufficient Training: CAMS System	10	27
Q24	Difficulty in Locating Correct Codes in T.O.s	10	17
Q25	Difficulty in Using Multiple Screen Entry	10	24
Q26	Computer Malfunction	0	11
Q27	Other Causes	0	4
Totals		50	113

The results reflect that, on average (the mean response), the maintenance personnel feel 27% of the information input into

CAMS is inaccurate. The greatest number of maintenance personnel (the modal response) felt that 10% of the information input into CAMS is inaccurate.

The "nature" of data inaccuracy is indicated by the results from questions 14 and 15. The results indicate that, on average, maintenance personnel felt 25% of the total error was intentional, while the greatest number of maintenance personnel felt 10% of the total error was intentional. The results also indicated that, on average, maintenance personnel felt 57% of the erroneous information was input into CAMS accidentally, while the greatest number of maintenance personnel felt that 90% or more of the errors are due to accidental causes. Note here that the sum of the "averages" (25% and 57%) for questions 14 and 15 did not quite add to 100%, but the modal responses do. However, as Figure 3 indicates, the distribution of responses to question 15 was "bowl" shaped, suggesting the presence of divided opinion. Additionally, the respondents may not have ensured that their responses for questions 14 and 15 added to 100%.

The "causes" of intentional errors were indicated by the results of survey questions 16 through 20. The maintenance personnel felt that, on average: 09% of the intentional errors were due to pressure to falsify/misrepresent the information, 25% of the intentional errors were due to lack of adequate time to accurately input information, 20% of the intentional errors were due to personnel not perceiving any benefit from entering accurate information, 36% of the

intentional errors were due to the difficulty in entering the data, and 11% were due to other reasons.

The "causes" of accidental errors were indicated by the results of survey questions 21 through 27. The maintenance personnel felt that, on average: 16% of the accidental errors were due to keystroke errors, 14% of the accidental errors were due to insufficient training on the T.O. system, 27% of the accidental errors were due to insufficient training on the CAMS system, 17% of the accidental errors were due to difficulty in finding the correct codes in the T.O. system to input into CAMS, 24% of the intentional errors were due to the difficulty in using the multiple screens that CAMS requires for certain types of data entry, 11% of the accidental errors were due to computer malfunction, and 4% of the accidental errors were due to other causes. Note here that the sum of the percentages for the accidental errors is 113%. However, due to the number of the possible causes provided in the survey and the standard deviation for each cause, it was felt that the means of the responses for the survey questions still provided an accurate characterization of the contribution to accidental errors by each cause.

Second Objective. Identify any variance of the responses across MAJCOMS or rank structure. To accomplish this objective, a two-way ANOVA was conducted on the responses of the current research. Tables 6 and 7, presented in chapter 4, display the results of the ANOVA. Table 11 summarizes these results by MAJCOM and rank. It is

TABLE 11

SUMMARY OF RESPONSE VARIANCE BY MAJCOM AND RANK

QUESTION	MAJCOM	RANK	NO VAR	SIG LEVEL
Q5		*		p< .0019
Q6	*			p< .0158
Q7		*		p< .0166
Q8		*		p< .0438
Q9		*		p< .0033
Q10			*	
Q11		*		p< .0001
Q12	*			p< .0250
Q13		*		p< .0327
Q14		*		p< .0030
Q15			*	
Q16		*		p< .0047
Q17	*			p< .0008
Q19			*	
Q20			*	
Q21			*	
Q22			*	
Q23	*			p< .0014
Q24		*		p< .0018
Q25		*		p< .0145
Q26		*		p< .0499
Q27			*	

interesting to note, from Table 11, that there was significant variance in this analysis and that most of the variance is explained by rank. However, there was some variance explained by MAJCOM which will be analyzed first.

The first case where the responses differed by MAJCOM is question 6. The SAC maintenance personnel disagreed more than TAC maintenance personnel with the statement that CAMS provides timely feedback for the base-level managers. However, both groups tended to agree with that statement. Also, as indicated in the question 12 responses, the SAC maintenance personnel tended to think that the majority of inaccurate data that is input to the CAMS system was caused

by errors in providing the data required by the CAMS system. The TAC maintenance personnel felt that the majority of inaccurate data that is input into the CAMS system was caused by manipulation of the data to meet expectations. Additionally, as indicated in the question 17 responses, the SAC maintenance personnel tended to feel that the lack of adequate time to accurately input information to CAMS accounted for 30% of the intentional errors input to CAMS while, the TAC maintenance personnel felt this reason for intentional errors accounted for only 20%. Finally, as indicated from the question 23 responses, SAC maintenance personnel tended to feel that insufficient training on the CAMS system accounted for 20% of the accidental errors input into CAMS, while TAC maintenance personnel felt that this cause accounted for 30% of the accidental errors input into CAMS.

In the cases where the difference between the responses were accounted for by rank, as seen from Table 7, the maintenance personnel at the manager level tended to differ from the supervisors and workers in their perception of data inaccuracy. As seen from the results of question 5, the managers agreed more than the workers or supervisors with the statement that CAMS provides valuable information for base-level maintenance managers. In responding to question 7, the workers agreed more than the supervisors or managers with the statement that the CAMS system provides an accurate accounting of manhour utilization in the maintenance complex.

In answering question 8, the supervisors agreed more than the managers with the statement that inaccurate data is input to the CAMS due to the difficulty in accurately coding the information required by the CAMS system. (The perceptions between the supervisors and workers for this statement were not statistically significant at the .05 level.) Also, in responding to question 9, the supervisors disagreed more than the managers or workers with the statement that CAMS is a useful management tool which should be maintained by the Air Force. The managers in responding to question 11 felt that maintenance personnel are seldom pressured by superiors to manipulate the CAMS input, while the supervisors and workers felt that the pressure to manipulate the data was somewhat higher. In question 13, managers felt there was a lower percentage of inaccurate information input into CAMS than that perceived by supervisors and workers. Question 14 reveals that the supervisors perceived a higher percentage of intentional errors, as a portion of the total errors, than the managers. (The difference in perceptions between the supervisors and workers for this question was not statistically significant at the .05 level.) Question 16 reveals that the workers and supervisors felt the pressure to falsify/manipulate information was greater than that perceived by the managers. In responding to question 24, the workers perceived that the difficulty in finding the correct codes in the T.O. system to input to CAMS accounted for a greater percentage of the accidental errors than was

perceived by the supervisors and managers. Additionally, the responses to question 25 reveal that the supervisors perceived a higher percentage, than was noted by the supervisors or workers, of the accidental errors that were due to the difficulty in using the multiple screens CAMS requires for certain entries. Finally, in question 26, the managers felt that the percentage of accidental errors explained by computer malfunction was less than that perceived by the supervisors or workers.

Third Objective. Identify any changes in the perceptions of data inaccuracy under the CAMS environment when compared to the earlier MDC environment (Folmar:1986). To accomplish this objective, a three-way ANOVA was conducted for each of the survey questions 5-11 and 14 to compare the results of the current research to the same survey questions asked by Folmar (Folmar:1986). The results of the ANOVA revealed that there was a significant rank*study interaction for all of the survey questions except question 7.

Survey question 7 examined the perception that the system (CAMS or MDC) provided an accurate accounting of manhour utilization in the maintenance complex. There is no difference in the perception, based on MAJCOM ($p < .4260$), of SAC personnel (mean response=3.571) and TAC personnel (mean response=3.512) in their response to this question. Both slightly disagreed with the statement that the respective systems (CAMS or MDC) provide an accurate accounting of maintenance manhours. There was a significant difference

based on rank ($p<.0001$), in that managers (mean response =3.651) and supervisors (mean response=3.630) disagreed more than the workers (mean response=3.300) with the statement that the systems (CAMS or MDC) provided an accurate accounting of manhour utilization in the maintenance complex. There was also a significant difference based on study ($p<.0018$). Maintenance personnel felt CAMS (mean response=3.408) provided a more accurate accounting of manhour utilization in the maintenance complex than did the MDC system (mean response=3.637).

Figures 21 through 27, presented in Chapter 4, display the interactions observed in survey questions 5, 6 , 8-11, and 14. In each question there was significant rank*study interaction. Table 12 summarizes, by rank, the significant differences in perceptions identified between MDC and CAMS using Bonferroni's procedure (McClave and Benson:865).

TABLE 12

DIFFERENCES IN PERCEPTION IDENTIFIED BETWEEN MDC AND CAMS ENVIRONMENT BY RANK

QUESTION	MANAGERS	SUPERVISORS	WORKERS
Q5	p<.0001	p<.0009	not sig
Q6	p<.0002	p<.0001	not sig
Q8	not sig	p<.0002	not sig
Q9	p<.0001	not sig	not sig
Q10	p<.0001	p<.0011	not sig
Q11	p<.0001	not sig	not sig
q14	p<.0004	p<.0133	not sig

From Table 12, it is interesting to note that the responses to the questions at the worker level did not change

between the two studies. However, in general for questions 5, 6, and 10, managers and supervisors perceive that the data collection environment has improved under CAMS. In responding to question 8, as shown in Figure 23, only the supervisors agreed more with the statement that, under the CAMS environment, inaccurate data is input into the system due to the difficulty in accurately coding the information required by the system. Additionally, Figure 24 reflects that, in answering question 9, only the managers agreed more with the statement that CAMS is a useful management tool that should be retained by the Air Force. In responding to question 11, only the managers felt there was less pressure, under the CAMS environment, by superiors on subordinates to manipulate the data input. Finally, Figure 27 indicates a unique interaction. The managers felt that the percentage of inaccurate data that is due to intentional errors decreased under the CAMS environment while the supervisors perceived that it increased. The workers did not perceive any significant change under the CAMS environment.

Conclusions

This current research continued the investigation initiated by Capt Folmar (Folmar:1986). It identified the nature of data inaccuracy under the CAMS environment by categorizing the inaccuracy into intentional and accidental causes. The modal responses to questions asking the maintenance technicians to quantify the errors in each of

these categories indicated that 10% of the data inaccuracies were due to intentional causes while 90% were accidental. Therefore, the evidence suggests that these categories adequately described the data errors' "universe."

The responses to the causes presented to the maintenance technicians indicated that this research's initial attempt to categorize the possible causes for data inaccuracies was successful. This is supported by the fact that the respondents indicated very few other causes for intentional or accidental errors. This is not to say that other causes don't exist, but rather their impact on the causes already identified would probably be negligible. Additionally, the results indicate that the highest percentage of intentional errors (35%) were due to the difficulty in entering information into CAMS. Also, the results suggest that the highest percentage of accidental errors were due to insufficient training in using the CAMS system (27%) and difficulty in using the multiple screens that CAMS requires for certain types of data entry (24%).

Finally, in examining the possible explanations for variance in the ANOVA conducted in this research, rank was a significant contributing factor in all areas, especially in comparing the current research to Folmar's research (Folmar:1986). In this last case, without exception, the workers did not perceive any change in data inaccuracy under the CAMS environment. This should be of special concern because they are the people entering the data and an

explanation of why they did not perceive any change should be pursued. To facilitate this, several different lines of thought are posed, for further reflection, in the form of questions. First, are the managers and supervisors not aware of what is really being input into the maintenance information systems by the workers? Alternatively, was the environment, under the MDC system, not as the managers and supervisors perceived it to be at the time of Folmar's study? Finally, is it possible that the managers and supervisors correctly perceived a change which went unnoticed by the workers?

Recommendations

The evidence presented in the responses to the open-ended questions suggest some courses of action that may improve the CAMS data collection environment.

First, training is clearly perceived to be needed. The evidence gathered in this current research suggests, as indicated in the responses to survey question 29, inadequate training on CAMS to be the single most prevalent reason for errors occurring in the CAMS database. Additionally, when asked what they felt was the single most beneficial action that could be taken to reduce or eliminate data entry errors in the CAMS system, the number one response was to provide more quality training on the CAMS system. The perception of a training deficiency on the CAMS system suggests a good area for further research: identifying what type of training is

needed on CAMS and determining whether the training requirements are different across ranks and MAJCOMS.

The results of the current research also indicate that investigation is warranted concerning how to make the CAMS data collection environment more "user friendly." The number one response to question 28 and the number 2 response to question 32 were to make CAMS more "user friendly." Both of these questions asked what the maintenance personnel would do to improve the data collection environment. There were several comments about what "user friendly" features should be included with the most popular being "pull down menus", extensive "on-line help" functions, and elimination/reduction of multiple screen data entry requirements. The determination of requirements, costs, and trade-offs in this area is rich in its potential for future research.

One last area that is recommended for future research is assessment of the impact of data inaccuracies occurring under the CAMS data collection environment. This research quantified a general perception that errors are occurring, but it was beyond the scope of the research to quantify what happens after the incorrect information is processed through the system. This line of investigation could include impacts at the base, MAJCOM, and Air Force levels.

Appendix A: Survey Package

LS (Capt Jon Determan, AV 785-8989)

Core Automated Maintenance System Survey Package

Survey Respondents

1. Please take the time to complete the attached questionnaire and return it to us in the enclosed envelope within two weeks.

2. The survey, SCN 91-24, measures your perceptions and attitudes toward the current Core Automated Maintenance System (CAMS). The data we gather will become part of an Air Force Institute of Technology (AFIT) research project and may influence the design of future data collection systems.

3. Your individual response will be combined with others and will NOT be attributed to you personally. Your identity will remain completely anonymous.

4. Your participation in this research effort is completely voluntary, but we would certainly appreciate your help.

PAUL T. WELCH, Colonel, USAF
Associate Dean
School of Systems and Logistics

1 Atch
Questionnaire

SCN 91-24
Exp date: 1 Aug 91

INSTRUCTIONS

1. Do not write your name or your social security number on the survey questionnaire. All replies will be completely anonymous.
Please enter your AFSC, left justified, in the first 5 (or 4 spaces for cfficers) spaces of the identification number block in the bottom left hand corner of the answer form provided with the survey. Please use a "soft lead" (No. 2) pencil, and observe the following:

a. Make heavy black marks that fill in the space of the response you select.

b. Erase cleanly any responses you wish to change.

c. Make no stray marks of any kind on the response sheet.

d. Do not staple, fold or tear the response sheet.

2. Read all questions carefully. Mark the answer, on the answer sheet provided, that best describes your opinion on the question asked. Answer all questions to the best of your knowledge.

3. On the open ended questions, write your answers in the space provided. If more space is required, please attach any additional sheets required.

4. Upon completion, please place your survey and answer sheet in the enclosed return envelope and place the envelope in base distribution.

5. Please try to return the survey within two weeks so that we may get the results published as soon as possible.

6. Thank you for your time and cooperation.

Section I. Background Information

This section contains several items dealing with personal characteristics. This information will be used to describe the population of the study. If you feel a requested item of information may specifically identify you, please leave that item blank.

1. You are assigned to which major command?
   (1) Tactical Air Command (TAC)
   (2) Strategic Air Command (SAC)
   (3) Military Airlift Command (MAC)
   (4) United States Air Force Europe (USAFE)
   (5) Pacific Air Force (PACAF)

2. Your rank is?
   (1) AB - SSgt (2) TSgt - CMSgt (3) 2Lt - Col

3. How many full years have you worked in the aircraft maintenance field?
   (1) Less than 2 years
   (2) 2 but less than 5 years
   (3) 5 but less than 10 years
   (4) 10 but less than 15 years
   (5) 15 but less than 20 years
   (6) 20 years or more

4. How many full years have you worked with the CAMS system?
   (1) Less than 2 years
   (2) 2 but less than 5 years
   (3) 5 years or more

Section II. Please respond to the following statements as honestly and openly as possible. Use the following scale to answer questions 5-9.

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

5. CAMS provides <u>valuable information</u> for base-level maintenance managers.

6. The CAMS system provides <u>timely feedback</u> for base-level maintenance managers.

7. The CAMS system provides an accurate accounting of man-hour utilization in the maintenance complex.

8. Inaccurate data is input to the CAMS due to the difficulty in accurately coding the information required by the CAMS System.

9. The CAMS system is a useful management tool which should be retained by the Air Force.

10. Correct data is input in the CAMS system by maintenance personnel:

(1)	(2)	(3)	(4)	(5)
Always	Usually	Sometimes	Seldom	Never

11. Maintenance personnel are pressured by superiors to manipulate the CAMS input:

(1)	(2)	(3)	(4)	(5)
Always	Usually	Sometimes	Seldom	Never

12. The majority of inaccurate data that is input to the CAMS system is caused by

(1) Keystroke errors
(2) Error in providing the data required by the CAMS system (examples: work unit codes, how malfunctioned codes, action taken codes, job control numbers etc...)
(3) Manipulation of the input to meet expectations
(4) Computer malfunctions
(5) Other (specify)______________________________

Section III. Information Inaccuracy.

For the remainder of the survey, the questions consider information entered at the data element level. A data element is an item specifically identified by a field on the CAMS screen (ie...Work Unit Code, Job Control Number, How Mal Code etc...).

Use the following scale to answer questions 13-15. Special Note: Total for questions 14 and 15 must equal 100%.

(1)	0%	(6)	50%
(2)	10%	(7)	60%
(3)	20%	(8)	70%
(4)	30%	(9)	80%
(5)	40%	(10)	90% or more

13. In your opinion, what percentage of the data input into the CAMS system is inaccurate concerning maintenance actions that occurred?

14. What percentage of the inaccurate data is due to <u>intentional</u> errors? (Definition: Data the technician knows is incorrect at the time of entry.)

15. What percentage of the inaccurate data is due to accidental errors? (Definition: Data the technician does not know is incorrect at the time of entry.)

Use scale below to answer questions 16-20 to indicate what percent of total intentional error is caused by each of the items listed. Special Note: Total for questions 16-20 must equal 100%.

(1)	0%	(6)	50%
(2)	10%	(7)	60%
(3)	20%	(8)	70%
(4)	30%	(9)	80%
(5)	40%	(10)	90% or more

16. Pressure to falsify/misrepresent information.

17. Lack of adequate time to accurately input information.

18. Personnel do not perceive any benefit from entering accurate information.

19. Information is difficult to enter. (example: The number of screens CAMS requires to complete S/N and P/N time change items.)

20. Other. Please specify reason on this sheet and mark percentage (from above scale) on answer sheet.

____

Use scale below to answer questions 21-27 to indicate what percent of total accidental error is caused by each of the items listed. Special Note: Total for questions 21-27 must equal 100%.

(1)	0%	(6)	50%
(2)	10%	(7)	60%
(3)	20%	(8)	70%
(4)	30%	(9)	80%
(5)	40%	(10)	90% or more

21. Keystroke errors.

22. Insufficient training in using the T.O. system.

23. Insufficient training in using the CAMS system.

24. Difficulty in finding the correct codes in the T.O. system to input into CAMS.

25. Difficulty in using the multiple screens that CAMS requires for certain types of data entry.

26. Computer Malfunction.

27. Other. Please specify reason on this sheet and mark percentage (from above scale) on answer sheet.

Open Ended Questions

28. If it were in your power to change the CAMS system, what changes would you make and why? PLEASE BE AS SPECIFIC AS POSSIBLE.

29. What do you feel is the single most prevalent reason for errors occurring in the CAMS data base?

30. What type of data concerning maintenance actions is most often reported in error?

31. If you know any person(s) who intentionally inputs false data into the CAMS system, what are the top 3 most common reasons given for their actions?

32. In your opinion, what is the single most beneficial action we could take to reduce or eliminate data entry errors in CAMS?

Please feel free to use the remaining space to comment on the advantages, disadvantages, problems, or other important aspects of the CAMS system as you perceive it.

Appendix B: Data Table

190	45274	01111311134528021611250200
189	45274	01302230412222812161115 1200
188	4024	12101131113111917110112510 0
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237	4096	12301340112421120061334130 0
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240	46170	10301313114033712070411211 0
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246	4016	02401332223143744110202411 0
247	4096	02411022113111911170411130 0
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250	4016	02311140412151912350000550 0
251	4024	0230114031213551331211224 0.
252	45750	10101331310222807120121330 0
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258	46350	10211221212110914230114211 0
259	45799	11312331213071901180211132 0
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268	45471	0142112311212341512030331000
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273	4011	0220331221332190333111112310
274	.	0142011001312181216010504000
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287	4024	021101220140119060 4.123210.
288	45770	1122321031144200514001323100
289	4011	0232111101412121314122212100
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294	.	1041111111311191914014637300
295	.	0200111011341190109012116000
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301	.	1140124132343120007310301400
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303	.	014033304231316121 4.235572.
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307	.	1020122111222551213312311110
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309	.	0220121211311371531021502000
310	4021	022012322221541161201132 21.
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316	.	023113402221327022602222200
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319	.	110111211231219151302241100
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321	4024	022111431121355181002061100
322	30594	011012210122363217001440000
323	.	0241012301411190011.4221100
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329	4024	021013303231426123400033400
330	.	10203340141124671009851763.
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359	.	023011221033101000301112220
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361	4011	023011411131228111611111150
362	4024	0221133111231180333.111133.
363	45770	112111332121119152201144000
364	45571	102114414244728080201211102

365	.	002133300101728260202311210
366	45870	012022222..................
367	.	10212222101100111710011....
368	4024	021122321124191010180141200
369	.	113112322120422122 1.323211.
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371	.	0211133112214321323.103321.
372	.	000011222212343332113150100

Note: <.> indicates missing data point.

Appendix C: Open-Ended Question Responses

Question 28

Response Characterization	Number of Responses
Make more user friendly	66
Eliminate/Reduce multiple screens	47
Decrease CAMS downtime	46
Provide/Improve CAMS training	24
Decrease CAMS response time	23
Provide user defined screen capability	23
Provide on-line help	20
Re-evaluate data collection practices	17
Eliminate/Replace CAMS	16
Improve AFM 66-279	15
Set up remote CAMS flightline access	13
No changes	13
Use pull down menus	9
Eliminate automated forms or 781's	7

Question 29

Response Characterization	Number of Responses
Inadequate Training	93
Not motivated to make correct entries	37
Not user friendly	23
Difficulty in using multiple screen entry	22
CAMS won't accept correct information	21
Insufficient time for correct data entry	19
Difficulty in using -06 WUC manual	13
Not proficient with CAMS	11
Software/Hardware Malfunctions	10
Not enough terminal access	10
CAMS changed without informing users	10
Keystroke errors	9
Human error	9
Technicians don't perceive benefit	8
Inability to correct wrong entries	7
Poor CAMS documentation	7
Frustration	6

Question 30

Response Characterization	Number of Responses
Work Unit Codes	72
Action Taken Codes	69
How Malfunctioned Codes	62
Time Accounting	56

Question 30 (cont.)

Serial Number	27
Part Number	23
Narrative/Corrective Actions	20
Type Maintenance	12
When Discovered Code	11
Job Control Number	6

Question 31

Response Characterization	Number of Responses
CAMS won't accept correct entry	73
Insufficient time for correct entry	56
Don't intentionally input incorrect info.	54
Just don't care/not motivated	53
Inadequate Training	30
Inflating manhours	20
Supervisor pressure to alter input	19
Covering time for 8 hour shift	12
Avoiding "difficult" entries	8
Delay in entering due to CAMS downtime	8
Difficulty in using multiple screen entry	7

Question 32

Response Characterization	Number of Responses
Provide training	79
Make more user friendly	48
Include on-line help	17
Eliminate multiple screen entries	15
Improve CAMS documentation	12
Simplify system	12
Eliminate/Replace CAMS	11
Train special cadre for CAMS input	8
Reduce CAMS downtime	8
Provide user definition capability	7

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Vita

Captain Jon R. Determan was born on 11 October 1958 in Enid, Oklahoma, where he also graduated from Chisholm High School. In May 1976, he enlisted in the United States Air Force and attended Basic Training at Lackland AFB, TX. He was trained as an aircraft maintenance mechanic at Sheppard AFB, TX and was assigned to Mt Home AFB, ID in Oct 76. He served there until May 1980, when he separated from the Air Force and attended Oklahoma State University (OSU). In May 1984, Captain Determan received a Bachelor of Science Degree in Electrical Engineering Technology from OSU and also received a commission in the USAF through the AFROTC program. He was called to active duty in May 1984, and completed the Aircraft Maintenance Officer Course at Chanute AFB, IL in October 1984. He served as an aircraft maintenance officer at Columbus AFB, MS with the 14th Flying Training Wing from Nov 84 to Apr 88. He then served as an aircraft maintenance advisor and logistics planner in the Advanced Tactical Fighter, System Program Office at Wright-Patterson AFB, OH from April 1988 to May 1990. In May 1990, Captain Determan entered the School of Systems and Logistics, Air Force Institute of Technology, pursuing a Master of Science degree in Logistics Management.

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13. ABSTRACT *(Maximum 200 words)*
This research investigated the data collection environment under the Core Automated Maintenance System (CAMS), a computerized information system used in the Air Force's aircraft maintenance complexes. The research measured maintenance personnel's perception of the nature, extent, and causes of data inaccuracies occurring in the CAMS data collection environment. The nature was differentiated as being either intentional or accidental. Maintenance personnel felt that difficulty in entering information into CAMS accounted for the largest percentage of intentional errors and that insufficient training on CAMS accounted for the largest percentage of accidental errors. A comparison of this research to the results of earlier research, conducted by Capt Thomas Folmar, revealed that the rank of the maintenance personnel had a significant effect on their perception of improvement in data accuracy under the CAMS environment. Also, the maintenance personnel surveyed perceived that lack of training on CAMS was the most significant cause of data errors and suggested that a training program may help to improve the data accuracy. Finally, the evidence in this research suggests that further research be conducted in identifying CAMS training requirements and assessment of the impact of data errors occurring under the CAMS environment.

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